CHARLOTTE.

Attachment: CDOT Traffic Signal Manual
CDOT Lead-In Cable Spec.

QUESTIONS & ANSWERS #3

DATE: July 27, 2015

TO: Prospective Bidders

FROM: Jennifer Miloy

PROJECT: Mt. Holly-Huntersville Road and Couloak Drive
Traffic and Pedestrian Signals Installation
Project # CDOT-IMP-015-001

The following questions and answers are presented solely for information purposes and do not change any elements or aspects of the bid documents for this project.

1. Question: I have a couple questions regarding the cable. There are specs for the cable, but it doesn't detail anything physical about the cable. I need to know how many conductors are required for the 16AWG cable and I also need to know what type 1 lead in cable is. Specifications do not clarify.

   Answer: Conductor is 16 AWG 7 wire, used for the traffic signals, and 4 wire Belden used for the pedestrian signals ran back to the controller. The lead in cable is 2 pair Belden cable, 18 AWG, and is run from each induction loop detector to the controller, see attached Lead-In Cable Spec.

2. Question: There is mention of the Charlotte Department of Transportation Traffic Signal Manual, but I can't seem to find it anywhere. Please provide.

   Answer: Please see attached Manual.

3. Question: Please provide more details for the application of the standoff bracket. The one described in the first question and answers seemed to be too much for anything in this particular contract. Risers according to NCDOT standards are attached with straps so I am not sure what the application will be.

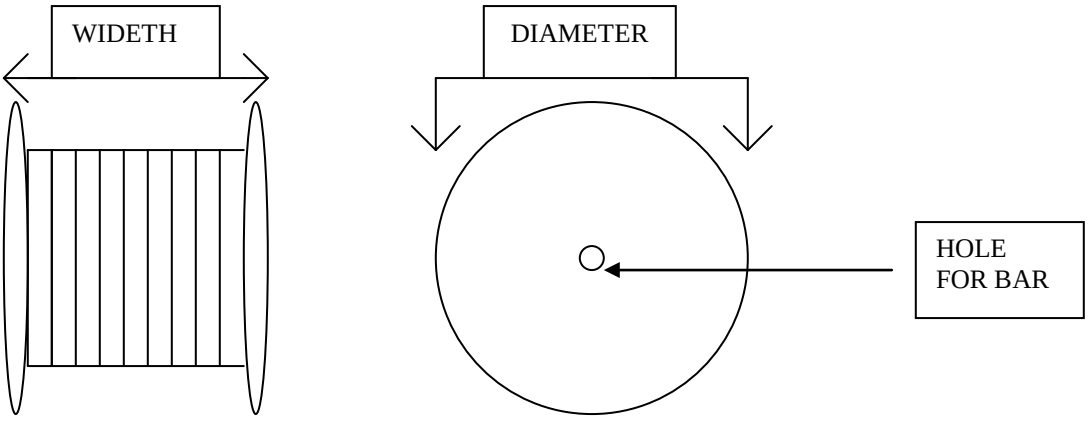
   Answer: The bracket bolts to the pole and holds the risers so the conduit is not clamped to the pole. Duke only allows us 2 conduits attached directly to the pole. You can see them on the signal at Monroe Road and Richland and Mount Holly Huntersville Road and Brookshire (HWY 16).

NOTES

Submit all questions, request-for-interpretations, or request-for-clarifications by e-mail immediately upon receipt of this Questions and Answers to Jennifer Miloy at jmiloy@charlottenc.gov.

End of Questions & Answers #3

CITY OF CHARLOTTE LEAD-In Cable IMSA 50-2 Specifications AND CDOT PART NUMBER T30120 DATED 11/2006



CITY OF CHARLOTTE Lead-In Cable Specifications

Construction details: This cable consists of 2 pairs of 18 AWG stranded tinned copper insulated with color coded polyethylene. Each pair is wrapped with a shield and drain wire. The shielded pairs are cabled together and wrapped with an over all shielding tape. Then a black polyethylene jacket is applied over the shielded core. The following information fully described this product.

Conductors:	18 AWG 16/30TC
Insulation:	Polyethylene .030” Wall .107 Dia
Color Code:	BLACK / WHITE, BLACK / RED
Ind. Shield:	Alum. / Mylan Foil-In
Ind. Drain Wire:	20AWG (10 / 30) TC
Overall Shield:	Alum. / Mylar-Foil-Out
Overall Drain Wire:	None
Jacket:	Black Polyethylene .030” Wall .335 Dia.
Print:	CDOT P/N # T30120 IMSA 50-2 YYYY
Footage:	**1000 foot reel** (+ or – 0%)

REEL SIZE

1. REEL SIZE FOR LEAD-IN CABLE----WIDETH OF REEL 12”
   HOLE FOR BAR 1-1/2”
   DIAMETER 15”TO 19”

THE BELDEN REEL CAN HAVE PLYWOOD SIDES

IF YOU HAVE ANY QUESTION PLEASE CALL KIM RHYNE
AT 704-336-2315 TO AVOID SHIPPMENT REFUSAL

SECTION 1
GENERAL REQUIREMENTS

1.1 INTENT

The purpose of this section of the *Traffic Signal Specifications*, hereinafter referred to as the *Specifications*, is to set forth the general requirements and administrative details governing traffic signal equipment and materials and their installation. All equipment and materials shall be furnished and installed in accordance with the specified requirements.

If construction or installation services of traffic signal equipment is necessary, the requirements of the NCDOT's *Standard Specifications for Roads and Structures* (hereafter referred to as the *Standard Specifications*) shall also apply. In the event of conflict between the requirements of the *Traffic Signal Specifications* and the *Standard Specifications*, the requirements of the *Traffic Signal Specifications* shall take precedence.

Unless otherwise noted, all equipment and materials shall be new.

Whenever a reference is made to any standard, specification or code, the reference shall mean the standard, specification or code specified, including amendments and addenda thereto, that is in effect on the date of advertising for bids.

All materials and work necessary to complete the work and to make complete, operating and fully functional systems shall be furnished whether or not specifically mentioned. Unless otherwise specifically noted in each instance, no unit shall be left unconnected or nonfunctional.

1.2 DEFINITION OF CONTRACT TERMS

The Definitions of Terms set forth in the *Standard Specifications* (Division 1, Section 101) shall apply. The following additional terms also apply.

Date of installation	The date, according to the Engineer's daily record of construction, that the equipment's operation is accepted and it begins normal continuous operation.
City	The City of Charlotte Department of Transportation.
MUTCD	*Manual on Uniform Traffic Control Devices for Streets and Highways* published by the United States Department of Transportation Federal Highway Administration.

1.3 SUBMITTAL DATA

Various items must be submitted to the Engineer for review and acceptance. Prior to the purchase or

fabrication of any such equipment or material, appropriate catalog cut sheets and specifications for all standard, off-the-shelf items and shop drawings and other necessary data for all non-catalog or custom-made items shall be submitted for review by the Engineer. All submittal data shall satisfy the documentation size requirements set forth in paragraph 1.5.2, except that sepias may be submitted instead of vellums. Unless otherwise noted, three (3) copies of 216 mm x 279 mm submittal information and one (1) reproducible sepia of all larger submittal information shall be submitted. One (1) copy of the 216 mm x 279 mm documentation and the sepia, both with appropriate notations, will be returned after the review.

The purpose of the submittal data is to show specifically and in detail that the specified requirements will be satisfied, in order to avoid non-conformance with those requirements which does not become apparent until it is too late to correct without serious consequences. For this reason, unusually detailed submittal data is required prior to acceptance of many of the items. If preprinted literature, such as catalog cut sheets, is used to satisfy some or all of the submittal data requirements, there shall be no statements on the literature which conflict with the specified requirements. Any such statements shall be crossed off and initialed. If a cut sheet shows more than one (1) option, the option(s) that will be provided shall be clearly indicated.

Each item of submittal data shall be clearly labeled with the item number of the item to which it applies in order to facilitate review. Each submittal shall contain sufficient information and details to permit full evaluation of the item and its interrelationship with other items. Submittals which, in the judgement of the Engineer, are insufficient to permit proper evaluation, will not be reviewed. All of the specified requirements shall be carefully addressed in the submittal data. Nothing shall be left to assumption. The functional and technical interrelationships among the various items shall be carefully addressed. In order to facilitate the Engineer's review when preprinted manuals or other documentation are used to describe compliance with the requirements for closed-loop systems or other computerized systems, a photocopy of the specified requirements (both functional and equipment) for such system shall be included with the submittal data. This photocopy shall be annotated to indicate specifically where, by page and paragraph, the specified requirements are addressed in the submittal data.

Each element of submittal data shall be clearly marked with the item(s) to which it applies. An element is one part of several parts of information related to the same item. Each drawing shall have a unique drawing number which can be referenced. The same drawing number shall not be used on more than one (1) sheet.

Following review of the submittal data, the Engineer will mark the items in one (1) of three (3) ways: "approved", "approved as noted", or "rejected". Any items marked "approved" may be purchased or fabricated. Items which are marked "approved as noted" are judged to be basically acceptable, but will

have notations made on them about additional information required or corrections which are necessary before the items can be accepted. In such case, said items shall be corrected and resubmitted for review. Items which are marked "rejected" are judged to be basically unacceptable and shall be replaced with alternate items or shall be redesigned and resubmitted for review.

1.4 CERTIFICATION

When requested, the manufacturer(s) shall certify, in writing in a form acceptable to the City, that the equipment being furnished meets all specified requirements. Additional certification(s) from an independent testing laboratory shall also be furnished by the manufacturer(s) when requested. The report shall also state that the testing laboratory is independent of the controller manufacturer and that neither the laboratory nor the controller manufacturer has any vested interest in the other.

1.5 DOCUMENTATION

As-built documentation of the work shall be provided as indicated below prior to acceptance of the work. All documentation shall satisfy the documentation size requirements set forth in paragraph 1.5.2. All as-built documentation shall be subject to the approval of the Engineer prior to acceptance.

In addition to the documentation specified below, two (2) manuals of each type and two (2) prints of each schematic diagram and cabinet wiring diagram applicable to each control equipment cabinet and the equipment in it, shall be provided and shall be placed in a weatherproof holder which is provided and mounted within each cabinet or housing for easy access. No documentation placed in the cabinet shall be on blueline paper. All wiring diagrams and schematic diagrams not bound into printed manuals shall be on bond paper at least 559 mm x 914 mm. All bond documentation shall be stored in a manila envelope and placed in the weatherproof holder. Documentation, including two (2) operator's manuals, for equipment purchased for stock by the City shall be packaged with the equipment in its shipping container.

1.5.1 Types of Documentation Required

The as-built documentation shall consist of the following documents as a minimum and as applicable. Required manuals and other documentation may be combined.

1.5.1.1 Operator's Manuals

A manual containing detailed operating instructions for each different type or model of equipment shall be furnished. This manual must also contain instructions for possible modification to the equipment within the capability of the equipment.

1.5.1.2 System Software User's Manual

When a closed-loop system or other type of computerized system is furnished, a user's manual or manuals shall be furnished covering the proper use of all traffic signal applications software furnished for the microcomputers or computers. This manual(s) shall be written from a traffic engineering perspective and for use by personnel who have virtually no understanding of the operation of a computer system.

1.5.1.3 Maintenance Procedures Manuals

A manual containing detailed preventive and corrective maintenance procedures shall be furnished for each different type or model of equipment.

1.5.1.4 Cabinet Wiring Diagrams

A cabinet wiring diagram shall be furnished for each different cabinet, identified by location.

1.5.1.5 Electrical Schematic Wiring Diagrams

An electrical schematic wiring diagram shall be furnished for each different type or model of equipment.

1.5.1.6 System Connection Diagrams

Connection diagrams for system interconnection cables and associated terminations shall be furnished.

1.5.2 Formats and Quantities of Documentation

At least five (5) copies of all bound documentation shall be furnished, except that only one (1) set of manuals shall be required for commercially available software packages, such as word processors and spread sheets. Except for standard bound manuals, all 216 mm x 279 mm documentation, including 279 mm x 432 mm drawings folded to 216 mm x 279 mm, shall be bound in logical groupings in loose-leaf binders of either the 3-ring or plastic slide-ring type. Each such bound grouping of documentation shall be permanently and appropriately labeled.

All documentation which exceeds the size of 216 mm x 279 mm shall be furnished in the form of good quality, highly legible, reproducible vellum drawings; however, the use of 279 mm x 432 mm drawings folded and bound into 216 mm 279 mm manuals shall be permitted without the need for vellums. These vellum drawings may be vellum, sepias, or photographically created vellums of the original drawings. Only one (1) copy of such reproducible vellums is required in each instance; however, a separate vellum of the cabinet wiring diagram for each control equipment cabinet, labeled with the location

name and number, shall be required even though some of the cabinets may be wired identically. All vellums shall be 559 mm x 914 mm, unless otherwise approved by the Engineer in each instance, and shall be reverse-reading. If smaller drawings exist, they shall be placed in the lower left-hand corner of the 559 mm x 914 mm vellum sheets. All vellums shall be either single-matte or double-matte. If single-matte, the text shall read correctly when viewed from the matte side. Vellums shall not be folded or creased in any way.

1.6 GUARANTEES

All of the equipment, materials and workmanship supplied under these *Specifications* shall be fully guaranteed for at least two years. All warranties and guarantees that are customarily issued by the equipment manufacturers which exceed this requirement shall be acceptable to the City. The warranty period shall begin on the date of the final acceptance of all work if contractor supplied, or on the date of delivery to the City if supplied to the City by a manufacturer or manufacturer's representative. This guarantee shall cover all parts and labor necessary or incidental to the repair of any defect in equipment or workmanship and malfunctions that arise during the guarantee period. The guarantee shall be provided to the City in writing prior to final acceptance of the work or material. The guarantee shall unconditionally cover all specified requirements. The wording of the guarantee shall be subject to the approval of the Engineer.

The warranties and guarantees delivered by the manufacturer to a contractor shall include the provision that they are subject to transfer to the City or its designated maintaining agency, and shall be accompanied by proper validation by the manufacturer. Transfer of warranties and guarantees to the City shall occur at the time of acceptance of the work.

Workmanship supplied in the installation of equipment and materials under these *Specifications* by a contractor shall be fully guaranteed for a minimum period of one year from the date of final acceptance of all work.

1.7 SOFTWARE LICENSING AND UPDATES

Each control equipment manufacturer shall furnish to the City updates of the software contained in, used by or related to the operation and maintenance of equipment furnished to the City as follows. Updates provided for equipment purchased for use on the National Highway System with Federal Aid shall require only that updates be supplied to correct deficiencies in the operation of the equipment, and this requirement shall be limited to the warranty period. In no case shall the period in which updates are provided to the City be shorter than the usual and customary period offered by the manufacturer.

1.7.1 Equipment Software and Firmware Updates

Each control equipment manufacturer shall furnish all control equipment program updates, including updated documentation, to the City for a minimum period of five (5) years from the date of acceptance of the equipment at no additional cost to the City. For this purpose, program updates are defined as adjustments to the equipment's software or firmware programming to correct errors and to provide minor enhancements. It is not intended that new programs or major revisions (new versions) of existing programs be provided. Furthermore, this requirement is not intended to apply to personal type computers. Software shall include programming of any standard programmable logic device (PLD), including PALs, ROMs, PROMs, EPROMs, EEPROMs and MCUs. All software and firmware updates shall be furnished either as readable programmed devices or as JEDEC or binary files on 1.44 Mega-byte diskettes, as applicable, for downloading from a personal computer to appropriate programming devices..

1.7.2 Control Equipment Related Personal Computer Software Updates

Each control equipment manufacturer shall furnish to the City updates, including updated documentation, of all control equipment related personal computer software that is furnished to the City with or for the control equipment for a minimum period of five (5) years from the date of acceptance of the associated control equipment at no additional cost to the City. For this purpose, program updates are defined as adjustments to the related equipment's personal computer software programming to correct errors and to provide minor enhancements. It is not intended that new programs or major revisions (new versions) of existing programs be provided. The software updates shall be furnished on the same medium as the originally furnished software.

1.7.3 Closed-Loop System Software Updates

Each closed-loop system manufacturer shall furnish to the City updates, including updated documentation, of all closed-loop system traffic applications personal computer software that is furnished to the City with or for the closed-loop system for a minimum period of five (5) years from the date of acceptance of the associated system at no additional cost to the City. For this purpose, program updates are defined as adjustments to the related equipment's traffic applications software programming to correct errors and to provide minor enhancements. It is not intended that new programs or major revisions (new versions) of existing programs be provided. Furthermore, it is not intended that updates be provided for computer operating systems, word processing software, spreadsheet software or other standard software that is not related to the traffic control, monitoring or reporting functions of the systems. The software updates shall be furnished on the same medium as the originally furnished software.

1.7.4 Software Documentation Updates

Required updates of written documentation shall be provided in the same number as were originally provided.

1.7.5 Software Licensing

The City shall be licensed by the manufacturer to copy and utilize all software updates, including documentation, in all equipment and on all personal computers owned or under the control of the City. The City shall also be licensed to copy and utilize all firmware or software provided in equipment purchased for the maintenance of equipment under control of the City. Any software or firmware devices (as defined in Section 1.7.1) installed in equipment shall be readable (not copy protected), or a copy shall be furnished to the City in a format required by Section 1.7.1.

1.8 IDENTIFICATION OF EQUIPMENT

Each piece of traffic control equipment which is housed in a case or housing shall have permanently inscribed on the exterior of said case or housing the manufacturer's name, model number, serial number, and any additional data needed for proper identification. Identification information for cabinets shall be permanently inscribed on the interior of the door.

SECTION 2
PRETIMED TRAFFIC SIGNAL CONTROLLERS

SECTION 3
ACTUATED TRAFFIC SIGNAL CONTROLLERS

These sections have purposely been omitted from these specifications. Signal controllers will be supplied by the City or will be purchased using the current North Carolina Department of Transportation traffic signal equipment specifications and/or the project special provisions.

SECTION 4
CONFLICT MONITORS

This section of the *Specifications* sets forth the requirements for conflict monitors.

4.1 BASIC REQUIREMENTS

All conflict monitors shall conform to the requirements of Section 1 and the following requirements.

4.1.1 All conflict monitors furnished shall be new.

4.1.2 All conflict monitors furnished shall meet the requirements of Section 6 of the NEMA Standards Publication TS1-1989, *Traffic Control Systems* (TS-1 Specifications), published by the National Electrical Manufacturers Association.

4.1.3 All electronic components used in the conflict monitor shall be commercially available components which may be supplied by electronics supply houses. No proprietary components shall be used in the conflict monitors.

Exception: The City may permit, at its discretion, equipment with proprietary components to be supplied if the manufacturer agrees to supply the proprietary components to the City for repair purposes for a minimum period of five years. If the components are no longer available during this period, the manufacturer shall replace or otherwise repair any unit in which the component fails during that period at the price of the discontinued component.

4.1.4 The decision to perform warranty work by the City of Charlotte electronics technicians or to have warranty work performed by the vendor shall be at the discretion of the City. Bench repair training on the manufacturer's equipment shall be provided as required by the bid document or plans at no additional cost to the City unless otherwise specified. In addition to any formal training requirements, the manufacturer shall agree to provide the following upon request: 1) Prompt technical support to the City repair personnel during the contract and for a period of one year after the end of the warranty period at no cost to the City 2) Parts shall be supplied by the vendor to the City for all warranty repairs at no cost to the City (defective parts replaced under warranty by the Electronic Systems Lab will be returned to the vendor for examination at the vendor's request). 3) Schematics and other documentation required to perform bench repair shall be sent to the Electronic Systems Lab within two weeks of request. Upon request from the

vendor, the City agrees not to divulge any proprietary information contained in those documents. At the request of the City, the vendor shall perform warranty repairs to equipment which fails during the warranty period at no cost to the State including freight costs to ship repaired equipment back to the Electronic Systems Lab. The City shall pay freight charges to ship equipment to the vendor or manufacturer. All equipment shall be repaired and returned to the City within twenty-one (21) calendar days of receipt by the manufacturer.

4.1.5 The manufacturer's name, model number, serial number, and any other information necessary for proper identification shall be permanently inscribed on each piece of equipment covered by this section of the Specifications.

4.2 FUNCTIONAL REQUIREMENTS.

4.2.1 The absence of the programming card shall cause the conflict monitor to trigger, and remain in the triggered state until reset.

4.2.2 The conflict monitor shall recognize the following faults, in addition to those specified by NEMA TS–1 Section 6, and shall trigger as required by the NEMA Specifications:

A. Yellow indication missing or shorter than 2.7 seconds (with ± 0.1 second accuracy);
B. Walk indication without green vehicle indication on same channel;
C. Dual Indications.

The tests for short and missing yellows and for dual indications shall be turned on or off per channel. The test for walk without green shall be selectable for each unit. The conflict monitor shall remain in the triggered state until the unit is reset unless otherwise specified.

4.2.3 When the conflict monitor is triggered, it shall provide a visual indication of the type of event which triggered the unit. These indications and the status of each channel shall be retained until the conflict monitor is reset.

4.2.4 The conflict monitor shall allow user selectable latching of the CVM, 24V I, and

24V II inputs. When the monitor is set for latching operation and one of these events is triggered, the conflict monitor shall be required to be reset before returning to normal operation.

4.3 PHYSICAL REQUIREMENTS.

4.3.1 Where required by the plans or bid list, the conflict monitor shall be supplied with a wiring harness set. Each harness shall be fitted with the proper connector and shall be three meters long.

4.3.2 The conflict monitor shall have the number of channels required by the plans, bid list or specifications.

4.3.3 All circuit boards shall have a moisture resistant coating.

4.4 ADDITIONAL REQUIREMENTS FOR LOGGING MONITORS

If the plans or the bid list require a logging conflict monitor, the conflict monitor shall conform to all of the requirements of Articles 4.1 - 4.3 and the following additional requirements.

4.4.1 The conflict monitor shall have an RS-232C serial communications port for the connection of a serial printer using ASCII codes.

4.4.2 The conflict monitor shall retain in nonvolatile memory at a minimum, the most recent nine (9) fault occurrences and the most recent ten (10) power failures. The conflict monitor shall have an internal time-of-year clock that will allow log entries to be identified by date and time-of-day. Each entry shall be so identified.

4.4.3 The conflict monitor shall, upon request, cause the most recent nine (9) (minimum) faults to be printed.

SECTION 5
VEHICLE DETECTORS

This section of the *Specifications* sets forth the requirements for both digital loop type vehicle detectors (also referred to as detector amplifiers or loop detector units) and magnetometer vehicle detectors. All vehicle detectors shall conform to the requirements of Section 1 of these *Specifications* and to the following requirements. Requirements for microloop detector elements may be found in Section 16.

5.1 GENERAL REQUIREMENTS

All vehicle detectors shall conform to the following requirements.

5.1.1 All detectors furnished shall be new.

5.1.2 The detector shall conform to the requirements of NEMA TS1-1989 Section 15 or NEMA TS2-1992 Section 6.5, "Inductive Loop Detectors," except as superseded or modified by this section of the Specifications. For the purpose of these specifications, the loop and its associated lead-in cable are not considered part of the Inductive Loop Detector.

5.1.3 All electronic components used in the detector shall be commercially available components which may be supplied by electronics supply houses. No proprietary components shall be used in the detectors.
Exception: The City may permit equipment with proprietary components to be supplied if the manufacturer agrees to supply the proprietary components to the City for repair purposes for a minimum period of five years. If the components are no longer available during this period, the manufacturer shall replace or otherwise repair any unit in which the component fails during that period at the price of the discontinued component.

5.1.4 The decision to perform warranty work by the City of Charlotte electronics technicians or to have warranty work performed by the vendor shall be at the discretion of the City. Bench repair training on the manufacturer's equipment shall be provided as required by the bid document or plans at no additional cost to the City unless otherwise specified. In addition to any formal training requirements, the manufacturer shall agree to provide the following upon request: 1) Prompt technical support to the City repair personnel during the contract and for a period of one year after the end of the warranty period at no cost to the City 2) Parts shall be supplied by the vendor to the City for all warranty repairs at no cost to the City (defective parts replaced under warranty by the Electronic Systems Lab will be returned to the vendor for examination at the vendor's request). 3) Schematics

and other documentation required to perform bench repair shall be sent to the Electronic Systems Lab within two weeks of request. Upon request from the vendor, the City agrees not to divulge any proprietary information contained in those documents.

At the request of the City, the vendor shall perform warranty repairs to equipment which fails during the warranty period at no cost to the City including freight costs to ship repaired equipment back to the Electronic Systems Lab. The City shall pay freight charges to ship equipment to the vendor or manufacturer. All equipment shall be repaired and returned to the City within twenty-one (21) calendar days of receipt by the manufacturer.

5.1.5 The manufacturer's name, model number, serial number and any other information necessary for proper identification shall be permanently inscribed on each detector.

5.1.6 Operating instructions for shelf mounted detectors shall be permanently inscribed on the detector.

5.2 PHYSICAL REQUIREMENTS.

5.2.1 All shelf mounted detector shall be housed in a durably finished nonferrous case. Removal of the case shall be accomplished by the use of simple hand tools.

5.2.2 All circuit boards shall have a moisture resistant coating.

5.2.3 All components of shelf mounted detectors shall be readily accessible with the case removed.

5.2.4 A 1.8 meter long (minimum) wiring harness shall be supplied with each shelf mounted detector. Each wire shall be permanently labeled, numbered or color-coded. The loop wires shall be twisted to within 13 mm of the connector.

5.3 ELECTRICAL REQUIREMENTS.

5.3.1 Lightning and surge protection shall be incorporated into the design of the detector. It shall not be necessary to add external surge protection devices.

5.3.2 Each channel shall be capable of tuning to and operating on any loop system inductance within the range of 50 to 2,000 μh. The channel shall operate properly on a loop system which has a single-point short to earth ground.

5.4 FUNCTIONAL REQUIREMENTS.

5.4.1 The detector shall register a permanent call during tuning operations, as a result of a loop fault, and when power is removed.

5.4.2 The detector shall be completely self-tuned within 10 seconds after application of power or restoration of interrupted power and within 10 seconds after correction of a loop fault.

5.4.3 Each multi-channel detector amplifier shall sequentially scan each of its channels.

5.4.4 Each channel shall have a minimum of eight (8) sensitivity levels.

5.4.5 On a multi-channel detector, it shall be possible to turn a channel off and disable its operation from the front panel.

5.4.6 Each channel shall monitor the loop for fault conditions. Upon detection of a fault condition, the monitor shall provide an indication of the occurrence and shall maintain the indication until manually reset, even if the condition is subsequently corrected. The fault conditions are:

- An open-circuited loop system
- A short to ground
- A 25 percent reduction in inductance

5.4.7 When the test specified in NEMA TS-1 paragraph 15.2.17.1 or TS-2 paragraph 6.5.2.17.1 is performed, the output shall be maintained for a minimum of 4 minutes. When the same test is performed with a Class 3 vehicle, the output shall be maintained for a minimum of 30 minutes, but not more than 120 minutes.

5.4.8 If specified, the detector shall be equipped with timing features. Delay shall be adjustable in one second increments (maximum) over the range of zero to thirty seconds (minimum). Extend shall be adjustable in one quarter (1/4) second increments (maximum) over the range of zero to fifteen seconds (minimum). It shall be possible to set both delay and extend timing for the same channel. If both timings are set, the delay shall operate first. After the delay condition has been satisfied, the extend timer shall operate normally. It shall not be necessary to satisfy the delay timing for an actuation arriving during the extend portion.

5.4.9 A Two-Channel Detector shall operate normally with the same loop connected to both channels.

5.5 MAGNETOMETER DETECTORS

This article sets forth functional and design requirements for a magnetometer vehicle detector which operates by measuring the difference in the level of the earth's magnetic field caused by the passage or presence of a vehicle within its zone of influence. The magnetometer detector shall consist of a control unit and the probes (sensors). The magnetometer detector shall conform to the requirements of Article 5.1 and the following requirements.

5.5.1 Detection shall be possible for all vehicles at speeds from 0 to 130 km/h. Only one (1) actuation per vehicle shall be allowed for each sensor.

5.5.2 The control unit shall have two (2) separate channels and each channel shall accept from one (1) to at least twelve (12) probes connected to it in series. The number of probes to be furnished with each channel shall be as specified on the bid list or plans.

5.5.3 Parked or stalled vehicles over the probes on a channel or damaged probes on a channel shall have no effect on the operation of the other channel.

5.5.4 The detector shall, as a minimum, provide both presence and pulse modes of operation. In the presence mode, the control unit shall provide an output as long as a vehicle remains in the detection zone. In the pulse mode, a pulse of 125 milliseconds ± 25 milliseconds duration shall be provided.

5.5.5 Each channel of the detector shall detect bicycles, motorcycles and other licensed vehicles when the probes are installed according to the manufacturer's specifications.

5.5.6 The control unit shall be designed to provide the output via a relay or an optically isolated solid state device for each channel as required by the plans or bid list. The output shall conform to the requirements of paragraphs 15.2.27.1 (for relays) or 15.2.27.2 (for solid state devices) of the NEMA Standards Publication TS-1.

5.5.7 Each probe shall include at least 9.1m of low-capacitance lead-in cable. The lead-in cable shall be 4-conductor cable with minimum A.W.G. #18 stranded conductors. The cable shall have a polyethylene jacket and shall be filled with a water-blocking material. Longer lengths of lead-in cable shall be provided if required by the bid list or the plans.

5.5.8 The probes shall be unaffected by temperature change, water, ice and pavement deterioration.

5.5.9 Electrical connections for both input and output circuits shall be by means of an MS-type connector. All similar detectors shall be directly interchangeable without any wiring or component changes. Each detector shall be furnished with a 1.8m (minimum) properly coded wiring harness.

SECTION 6
SURGE PROTECTORS

This section of the *Specifications* sets forth the requirements for various types of surge protectors for use in the traffic signal control equipment specified elsewhere in these *Specifications*. The requirements of Section 1 of the *Specifications* apply to surge protectors.

6.1 POWER LINE SURGE PROTECTORS

The power line surge protector shall conform to the following requirements.

Peak surge current occurrences:	20 minimum
Peak surge current for an 8 x 20 microsecond waveform:	20,000 amperes
Clamp voltage at 20,000 amperes:	280 maximum
Maximum continuous operating current at 120 volts, 60 Hertz	10 amperes
Series inductance (nominal):	200 microhenrys
Temperature range:	-40 to +85 degrees Celsius
Maximum dimensions:	105 mm wide x 185 mm long x 77 mm high plus studs
Voltage Suppression:	Voltage never exceeds 280 volts during surge
Spike suppression for ±700 volt spike:	±40-volt deviation from sine wave at all phase angles from 0 to 180°

Filtering:

Frequency (Hertz)	Minimum Insertion Loss (dB)
60	0
10,000	30
50,000	55
100,000	50
500,000	50
2,000,000	60
5,000,000	40
10,000,000	20
20,000,000	25

The unit shall be a two-stage device that will allow the connection of the radio interference filter in the circuit between the stages.

6.2 LOOP DETECTOR SURGE PROTECTORS

This article sets forth the specifications for two (2) types of loop detector surge protectors: one (1) which mounts directly on terminal blocks and one (1) which mounts on a self-contained stud.

6.2.1 General Requirements

All loop detector surge protectors shall conform to the following requirements.

- Number of 100 ampere surge current occurrences of a 10 x 700 microsecond waveform:

Common mode:	at least 25
Differential mode:	at least 25

- Clamp characteristics (common and differential modes):

Maximum break-over voltage:	170 volts
Maximum on-state clamping voltage:	30 volts
Response time:	less than 5 nanoseconds
Off-state leakage current:	less than 10 microamperes

- Capacitance (common and differential modes): less than 220 picofarads
- Temperature range: -40 to +85 degrees Celsius
- Maximum dimensions: 51 mm x 51 mm x 32 mm

The surge protector shall operate properly with the loop type vehicle detectors specified in Section 5.

6.2.2 Type TB Loop Detector Surge Protectors

Type TB loop detector surge protectors shall conform to all of the requirements of paragraph 6.2.1. The Type TB surge protector shall have three (3) integral spade lugs that shall enable the unit to be mounted and connected directly to a terminal block. The Type TB surge protector shall be furnished for either 11.11 mm or 14.29 mm terminal spacing as required by the bid list or as required to match the terminal blocks to which it is to be connected in each instance.

6.2.3 Type SC Loop Detector Surge Protectors

Type SC loop detector surge protectors shall conform to all of the requirements of paragraph 6.2.1. The Type SC surge protector shall have an integral mounting ground stud with a minimum length of 9.5 mm and a maximum diameter of 4.9 mm with an associated mounting nut.

6.3 COMMUNICATIONS SURGE PROTECTORS

This article sets forth the specifications for two (2) types of communications surge protectors: one (1) which mounts directly on telephone-type quick-connect blocks and one (1) which mounts in a socket.

6.3.1 General Requirements

All communications surge protectors shall conform to the following requirements.

- Surge current occurrences at:
  - 2000 amperes, 8 x 20 microsecond waveform: at least 80
  - 400 amperes, 10 x 700 microsecond waveform: at least 80
- Peak surge current for:
  - 8 x 20 microsecond waveform: 10,000 amperes (2,500 amperes/line)
  - 10 x 700 microsecond waveform: 500 amperes/line
- Response time: less than 1 nanosecond
- Series resistance: 15 ohms, maximum
- Capacity, average: 1500 picofarads
- Temperature range: -40 to +85 degrees Celsius
- Clamp voltage: As specified on bid list or as required to match equipment in application.

The unit shall be a hybrid device with the first stage formed by a 3-element gas tube that will withstand a peak surge current (8 x 20 microsecond waveform) of 10,000 amperes per side. The second stage shall dissipate at least 1.5 kilowatts.

No tools shall be required for the insertion and removal of the surge protector.

6.3.2 Type Q Communications Surge Protectors

Type Q communications surge protectors shall conform to all of the requirements of paragraph 6.3.1 and shall be for use on communications circuits which are not subject to high-voltage ringing currents. The Type Q surge protector shall mount on and connect directly to a standard telephone-type quick-connect block (ATT Type 66M1 or equivalent). The Type Q surge protector shall have dimensions that allow Type Q surge protectors to be mounted adjacent to each other on the same quick-connect block in a way that does not render any of the quick-connect block terminals useless. The surge protectors shall have finger grips on one end for easy removal.

6.3.3 Type SC Communications Surge Protectors

Type SC communications surge protectors shall conform to all of the requirements of paragraph 6.3.1 and shall service up to two communications circuit pairs. The Type SC surge protector shall have a printed circuit board card-edge connector that will mate with a Buchannan PN PCB 1B-10A connector. The contact strips shall be gold-plated. The Type SC surge protector shall be furnished with a mating socket. The maximum size of the Type SC surge protector with its socket shall be 51 mm x 70 mm x 32 mm.

6.4 24-VOLT DC SURGE PROTECTORS

The 24-volt DC surge protector shall conform to the following requirements.

- Surge current occurrences at:
  2000 amperes, 8 x 20 microsecond waveform: at least 80
- Peak surge current for:
  8 x 20 microsecond waveform: 2,000 amperes
- Response time, maximum: 30 nanoseconds
- Series resistance, each conductor: 15 ohms, maximum
- Maximum dimensions: 32 mm wide x 32 mm long x 64 mm high plus stud
- Temperature range: -20 to +85 degrees Celsius
- Clamp voltage: As specified on bid list or as required to match equipment in application.

The unit shall be a hybrid device with the first stage formed by a 3-element gas tube that will withstand a peak surge current (8 x 20 microsecond waveform) of 5,000 amperes per side. The second stage shall dissipate at least 1.5 kilowatts.

The 24-volt DC surge protector shall have an integral mounting ground stud with a minimum length of 9.5 mm and a maximum outside diameter of 4.9 mm with an associated mounting nut.

SECTION 7
AUXILIARY CONTROL EQUIPMENT

This section of the *Specifications* sets forth the requirements for various types of equipment to be used with and generally located in the control equipment cabinets with other traffic control equipment covered by these *Specifications*.

7.1 GENERAL REQUIREMENTS

The requirements of Section 1 of these *Specifications* and the following general requirements apply to all items of auxiliary control equipment, unless otherwise noted.

7.1.1 Following a power interruption, the accessory shall resume normal operation.

7.1.2 The manufacturer's name, model number, serial number, and any other information needed for proper identification shall be permanently inscribed on each item of auxiliary control equipment.

7.1.3 No item of auxiliary control equipment shall be either altitude or position sensitive.

7.1.4 Each item of auxiliary control equipment shall be furnished with a connecting cable which shall have a minimum length of 3 m. The cable shall attach to the item by either a multi-pin connector or an MS-type connector. The raw ends of the harness conductors shall have labels indicating their functions.

7.1.5 Each item of auxiliary control equipment shall be housed in a durably finished metallic case or a shielded thermoplastic case. Any unused openings in the enclosure shall be neatly covered with blank panels designed to complement the unit's appearance.

7.1.6 Testing and Servicing Considerations

A. All components shall be arranged so that they are easily accessible for servicing.

B. All components used in the auxiliary control equipment shall be readily available from commercial electronics supply outlets, unless otherwise permitted by the City in each instance. A list of parts specifying at least two (2) equivalent makes and models for each part shall be furnished as part of the required documentation. If the City permits the use of components which are not available from commercial electronics supply outlets, a letter shall be submitted from the manufacturer of the auxiliary control equipment to the City agreeing to supply said components to the City and its maintaining agency (generally a municipality) for at least seven (7) years from final acceptance of all work under the contract.

7.1.7 Component Rating

All components shall be rated sufficiently beyond their actual minimum requirement in the auxiliary control equipment so that no material shortening of life will occur under conditions of maximum power dissipation at maximum ambient temperature.

7.1.8 Inductors and Transformers

All inductors and transformers shall have insulated windings. The insulation shall be impregnated to exclude moisture.

7.1.9 Resistors and Capacitors

All resistors and capacitors shall be insulated and shall be marked with their ratings. Ratings shall be indicated either directly with numerals or by the RETMA color codes. All electrolytic capacitors shall be marked to indicate their polarity.

7.1.10 Circuit Board Considerations

Circuit boards used in the auxiliary control equipment shall conform to the following requirements.

A. The components on all printed circuit boards shall be arranged for ease of access. The components shall be identified by markings on the components and on the boards.

B. Each printed circuit board shall be constructed of NEMA grade A, FR-4 or G10 glass cloth base epoxy resin board with a minimum thickness of 1.5 mm. All contacts shall be gold-plated and all through-holes shall be plated with copper to at least 305 g/m^2. All conduction tracks shall be copper plated to at least 610 g/m^2, except that the circuit board containing the display may have tracks of 305 g/m^2, and shall have an adequate width to accommodate the expected current.

C. Each printed circuit board shall have a conformal coating to retard the development of mildew.

7.1.11 Electronic Noise Protection

The power supply shall provide sufficient filtering and capacity to prevent transient voltage spikes from improperly triggering internal auxiliary control equipment components into operation.

7.1.12 Power Source

The unit shall operate properly from a 120-volt, 60-Hertz power source.

7.1.13 Controller Interface

All DC inputs and outputs of the unit that are intended to interface directly with a controller shall satisfy the requirements of Article 13.2 of NEMA Standards Publication TS-1.

7.1.14 Fuses/Circuit Breakers

Auxiliary control equipment shall be suitably protected by a fuse or circuit breaker. If fused, the fuse shall be replaceable by hand. The ratings of the fuses shall be labeled on a panel surface adjacent to the fuse holder.

7.2 TIME SWITCHES

This article of the *Specifications* sets forth the requirements for solid-state, seven-day, automatic time switches to be furnished as required by the bid list or the plans. The time switches shall conform to the requirements of Article 7.1 and to the following requirements.

7.2.1 The unit shall be of all solid state design, except for the output relay, and shall contain a real-time clock from which all time-selectable programs shall be derived.

7.2.2 The unit shall provide programming for one (1) full year or an automatic clock calendar which extends a minimum of twenty (20) years beyond the unit's delivery date.

7.2.3 During power outage, the real-time clock and memory shall continue to operate on an internal battery or capacitor backup power source. The backup power source shall supply the power for a single outage of 48 hours minimum. Automatic recharging of the battery or capacitor shall occur within 24 hours after resumption of power. The time shall be crystal controlled with an accuracy of ± 0.005 percent throughout the full temperature range.

7.2.4 The time settings and the real-time clock shall be programmable in increments of one (1) minute or less.

7.2.5 Means shall be provided for rapidly setting the real-time clock via the front panel.

7.2.6 There shall be indicating devices on the unit to indicate the time and day, battery condition, program in effect, and day of the week.

7.2.7 It shall be possible to manually synchronize the clocks in two (2) time switches to ± 1 second.

7.2.8 Means shall be provided for the manual selection of all programs via the front panel.

7.2.9 Lightning and surge protection shall be provided for all input and output terminals.

7.2.10 Each output circuit shall have a minimum rating of 10 amperes at 120 volts, 60 Hertz with a resistive load. Output relays shall have Form C contacts.

7.2.11 Daylight savings time data and feature enable shall be entered via the keyboard. Leap year compensation shall be automatic.

7.2.12 ll programming shall be accomplished via a push button keyboard which is an integral part of the time switch. The functions of the keys shall be clearly marked on the front of the time switch. Time-of-day, day-of-week, date, year and the operation of the relay output shall be easily settable from the integral keyboard.

7.2.13 The time switch shall be capable of initiating a minimum of sixteen (16) program steps. A program step is defined as the time of day and the day or days of the week at which the output shall be turned ON or OFF. It shall be possible to alter any individual program step without disturbing any other step in the program.

7.2.14 The time switch shall be capable of executing ten (10) separate skip plans programmable up to a year in advance to accommodate school holidays. Each skip plan shall be programmed by entering the beginning day (month/day/year) and the ending date for which the output of the time switch will not be activated. The time switch shall be capable of skipping as short a duration as one (1) day or as long as six (6) months. It shall be possible to begin a skip plan in one (1) calendar year and end that same plan in the next consecutive year.

7.2.15 Integral with the time switch shall be an easy to read alpha-numeric display. If time is kept in a 12-hour format, provision shall be made to display AM/PM.

7.2.16 A means shall be provided to review the time switch program via the keyboard. Such program review shall not affect the operation of the time switch.

7.2.17 The front panel of the time switch shall indicate the current day of the week, the current time of the day, the current date and the status of the output (ON or OFF).

7.3 LOAD SWITCHES

This article of the *Specifications* sets forth the requirements for load switches as required by the plans, the bid list or other sections of these *Specifications*. All load switches shall conform to the following requirements.

7.3.1 Each load switch shall be a three-circuit load switch conforming to the requirements of

Section 5 of NEMA Standards Publication TS-1, except that load switches having all components totally encapsulated on the connector shall be permitted.

7.3.2 All load switches shall be furnished with sturdy plugs which shall not crack due to careless insertion or removal of the load switches.

7.4 FLASHERS

This article of the *Specifications* sets forth the requirements for solid state flashers as required by the plans, the bid list or other sections of these *Specifications*. All flashers shall conform to the following requirements.

7.4.1 Each flasher shall be a Type 3 solid state flasher conforming to the requirements of Section 8 of NEMA Standards Publication TS-1, except that flashers having all components totally encapsulated on the connector shall be permitted.

7.4.2 Each flasher shall be furnished with a sturdy plug which shall not crack due to careless insertion or removal of the flasher.

SECTION 8
SPECIAL LOGIC UNITS

8.1 GENERAL

This section of the *Specifications* sets forth the requirements for various special logic units. The requirements of Section 1 of the *Specifications* apply to logic units. The design of each type of special logic unit shall be subject to the approval of the City. All equipment covered under this section shall meet the requirements of Paragraph 2.1.5 of NEMA Standards Publication TS-1.

8.1.1 Construction

Each logic unit shall be of solid state construction and shall either be housed in a suitable metal enclosure or be contained on a printed circuit card with a suitable card-edge connector. If the printed circuit card option is supplied, a suitable card rack shall also be supplied as part of the special logic unit. The design of the card rack shall be such that it shall be physically impossible to insert an incorrect card in a slot.

8.1.2 Power Supplies

The logic units shall be designed to operate on the 24-volt DC output from the controllers specified in Sections 2 and 3 of the *Specifications*.

8.1.3 Harnesses

Each special logic unit shall be equipped with a harness with a suitable connector. The harness shall be at least 3 m long.

8.1.4 Circuit Board Considerations

Circuit boards used in the special logic units shall conform to the following requirements.

A. The components on all printed circuit boards shall be arranged for ease of access. The components shall be identified by markings on the components and on the boards.

B. Each printed circuit board shall be constructed of NEMA grade A, FR-4 or G10 glass cloth base epoxy resin board with a minimum thickness of 1.5 mm. All contacts shall be gold-plated and all through-holes shall be plated with copper to at least 305 g/m^2. All conduction tracks shall be copper plated to at least 610 g/m^2 and shall have an adequate width to accommodate the expected current.

C. Each printed circuit board shall have a conformal coating to retard the

development of mildew.

8.1.5 Controller Interface

All DC inputs and outputs of the Special Logic Unit that are intended to interface directly with a controller shall satisfy the requirements of Article 13.2 of NEMA Standards Publication TS-1.

8.2 CALLING DETECTOR LOGIC UNIT

This article sets forth the requirements for a calling detector logic unit. The logic unit shall be suitable for installation between a detector unit and the associated detector input to the controller. The logic unit shall monitor the associated phase's green output and shall connect the detector to the controller during all displays of the controller except the associated phase's green interval. During the green interval, the logic unit shall disconnect the detector from the controller.

8.3 TWO-PULSE PEDESTRIAN DETECTOR LOGIC UNIT

This article sets forth the requirements for a two-pulse pedestrian detector logic unit.

8.3.1 Functional Operation

This logic unit shall be designed to cause the controller to display the associated phase's pedestrian intervals during the two (2) successive cycles immediately following actuation of the pedestrian detector which is connected to its detector input. The logic unit shall function to allow a pedestrian crossing a divided roadway to complete his crossing during two (2) successive signal cycles by crossing to the median on the first cycle and completing his crossing on the second cycle without the need for a pedestrian detector on the median.

8.3.2 Output

The output of the logic unit shall be suitable for connection to the pedestrian detector input of the associated phase of the controller.

8.3.3 Inputs

The logic unit shall have two (2) inputs. One (1) shall be a contact closure from a pedestrian push-button. The other shall be the WALK or GREEN output from a controller.

8.3.4 Signal Monitoring

The logic unit shall monitor the associated WALK (or GREEN, if no pedestrian signals) signal output of the controller as necessary.

8.3.5 Logic Reset

Each actuation of the associated pedestrian detector shall reset the logic to cause two successive displays following the most recent actuation.

8.4 DETECTOR SWITCHING LOGIC UNIT

This article sets forth the requirements for a detector switching logic unit. The logic unit shall be suitable for installation between a detector unit and the associated detector inputs to the controller. The logic unit shall monitor a specified phase's green output or other specified 120-volt signal and shall connect the detector to one (1) specified phase of the controller when the monitored signal in ON and to a second specified phase when the monitored signal is OFF.

SECTION 9
CONTROL EQUIPMENT CABINETS

This section of the *Specifications* sets forth the requirements for various types of control equipment cabinets. All cabinets shall conform to the following requirements. The requirements of Section 1 of the *Specifications* also apply. The following types of control equipment cabinets are covered in this section:

- Pretimed cabinets to house pretimed traffic signal controllers;
- Type 2 cabinets to house two-phase traffic signal controllers;
- Type 4 cabinets to house two-phase through four-phase traffic signal controllers;
- Type 8 cabinets to house two-phase through eight-phase traffic signal controllers;
- On-street master cabinets to house on-street master controllers; and
- Remote detector cabinets to house loop-type vehicle detector units remotely from an intersection traffic control cabinet.

9.1 GENERAL CABINET REQUIREMENTS

All cabinets shall conform to the following requirements unless otherwise noted.

9.1.1 Shop Drawings Required

Detailed shop drawings showing the dimensions, layout, labeling, back panel terminal facilities, and control circuit wiring of all cabinet models shall be submitted for the City's review prior to fabrication of the cabinets. The drawings shall show the location of all equipment and terminals within the cabinet in all three (3) orthogonal views in such a way that the accessibility of each item can be verified.

9.1.2 NEMA Standards

All cabinets shall conform to NEMA Standards Publication TS-1 (NEMA Specifications) published by the National Electrical Manufacturers Association, unless otherwise noted.9.1.3 Cabinet Size - General

9.1.3.1 Each cabinet shall be large enough to accommodate all of the required and specified future equipment and wiring within the cabinet in a manner that provides sufficient room for servicing and for possible additional equipment. Ample space shall be provided in the bottom of the cabinet for the entrance and forming of all necessary wires and cables without interference with the operation, viewing and servicing of the equipment. The size of the cabinet shall permit all required and specified future equipment to be mounted in the upright position with sufficient space around it to provide adequate ventilation. At least 50 mm clearance shall be provided around all vents and fans to insure proper air circulation.

9.1.3.2 The interior size of the cabinets shall be at least:

Remote detector cabinets:	68,800 cm^3
Pole- and pedestal-mounted controller cabinets:	141,000 cm^3
Base-mounted controller cabinets:	328,000 cm^3
Pole- and pedestal-mounted on-street master cabinets:	98,000 cm^3
Base-mounted on-street master cabinets:	213,000 cm^3

If specified on the bid list or the plans, controller cabinets as small as 93,000 cm^3 may be furnished for pole- and pedestal-mounted cabinets provided all other requirements of the *Specifications* are satisfied.

9.1.3.3 Unless otherwise noted, cabinets shall not exceed the following dimensions.

	Maximum Outside Dimensions		
Type of Cabinet	Height	Width	Depth
Pole-mounted	1320 mm	765 mm	560 mm
Pedestal-mounted	915 mm	765mm	560 mm
Base-mounted	None	None	None

9.1.4 Cabinet Construction

9.1.4.1 Materials

Walls and Top: The walls and top of the cabinet shall be sheet aluminum. Sheet aluminum shall be Aluminum Association alloy 5052H and shall be at least 2.5 mm thick.

Hardware: All hardware, including pins, hinges, and door handles, shall be of corrosion-resistant material.

9.1.4.2 One-Piece Surfaces

Each side, the top, and the bottom (if any) of the cabinet shall be a single piece of aluminum. The joining of more than one (1) piece of aluminum in any way to form any single side, the top, or the bottom shall not be permitted.

9.1.4.3 Welding

All welds shall be continuous, smooth and approximately flush with the surrounding surfaces.

9.1.4.4 Strength

The cabinet shall be sturdy and shall not exhibit noticeable flexing, bending or distortion under any normal conditions, even when the doors are open, except that a minor amount of flexing shall be permitted in the main door and rear door (if specified) only when it is open. In such case, the flexing shall not result in permanent deformation of the door or damage to components mounted on the door. The cabinet, including the doors, shall be adequately framed and braced to achieve these requirements. Pedestal-mounted cabinets shall have sufficient framing around the slipfitter attachment so that no noticeable flexing will occur at or about this point.

9.1.4.5 Door

A. Each cabinet shall have a main door. The door opening shall encompass the full frontal area of the cabinet and the door shall cover the entire opening. The door shall be hinged on the right side as viewed from the front.

B. The door shall have a lockable latching device which secures the door to the cabinet at the mid-point of the left side. Doors over 0.8 m tall shall have a 3-point, lockable latching device which secures the door to the cabinet at the top, bottom and the mid-point of the left side. The lock's drive pin connecting the handle to the lock mechanism shall have a minor cross-sectional dimension of at least 12 mm. The door handle shall be mounted through a brass bushing or by some equivalent method subject to the City's approval in order to keep the handle from freezing to the door. In order to prevent damage to the keys and the operators' fingers, the lock shall be designed and installed in such a way that it will be impossible to turn the lock handle into or over the key. The handle shall be vertical in the locked position and shall accommodate a padlock. The handle shall be connected to the locking plate via a secure means easily disassembled with hand -tools. The door handle and the locking rod assembly shall be easily disassembled using only simple hand tools. The locking plate shall be at least 4.5 mm thick and shall mate securely with the lock bolt for proper locking. The lock bolt shall have a flat end (no bevel allowed) and shall have approximately 13 mm of travel. The lock shall be keyed to a standard #2 Corbin (or equivalent) traffic control cabinet key. The lock's key receptacle shall be not extend more than 6.5 mm beyond the outside surface of the

door and shall have a cover.

C. At least two (2) keys shall be furnished with each cabinet. The grip of each key shall have an area of at least 500 mm^2.

D. The door shall have a retainer mechanism which will catch and hold the door in the fully open position at approximately 170 degrees. This mechanism shall also hold the door at the 90-degree position.

E. All doors shall be gasketed at the openings and the doors shall fit firmly and evenly against the gaskets when closed.

F. When specified on the plans or bid list, a rear door shall be provided on base mounted cabinets with a door opening which encompasses the entire area of the back panel. The door shall be provided with the features identified in paragraphs B, D,and E above.

9.1.4.6 Equipment Mounting

Shelves, slideways or wall- or shelf-mounted card racks shall be provided for the mounting of all current and specified future equipment. At least two (2) sturdy shelves shall be provided. The bottom shelf shall have an unobstructed depth of at least 460 mm. The top shelf shall be at least 305 mm below the top of the door opening, and shall have an unobstructed depth of at least 260 mm. Where card racks are used, they shall be secured to the walls or shelves. Equipment and components which are mounted on the cabinet walls shall require not more than the use of a screwdriver to accomplish their easy removal for servicing. It shall be possible to place shelf-mounted units in their proper positions on the shelves without having to twist or turn them during the placement process.

9.1.4.7 Roof

The cabinet shall have a roof that slopes slightly downward from front to back. The roof shall be equipped with a shield that prevents water from dripping into the cabinet. The roof shall also be equipped with an thermostatically controlled exhaust fan and suitable screened exhaust vents which will permit the flow of air for which the fan is rated. Base-mounted cabinets shall have a fan rated for at least 47 L/s and pole- and pedestal-mounted cabinets shall have a fan rated for at least 23 L/s. The fan shall not protrude to the outside of the cabinet and shall be mounted in such a way that it can be easily removed for servicing. The fan shall not require fusing. The roof assembly shall be formed in such a way that it facilitates air exhaust from the fan.

9.1.4.8 Cabinet To Be Weathertight

The cabinet shall be weathertight. It shall prevent the entrance of rain, splashed water, dirt, bugs and other foreign objects.

9.1.4.9 Neat Appearance

The cabinet shall be neat and clean cut in appearance. There shall be no superfluous holes in the outside of the cabinet. No nuts, screws or bolts shall protrude to the outside of the cabinet. The surface of the cabinet shall be smooth and free of blemishes and discolorations.

9.1.4.10 Mounting

The cabinet shall be furnished with all necessary mounting hardware. Pole-mounted cabinets shall be mounted by means of pole plates and 19 mm stainless steel straps for attachment to wood or metal poles or, if required by the bid list or the plans, by means of lag screws for attachment to wood poles. Pedestal-mounted cabinets shall be furnished with a 115 mm slipfitter to mate with the pedestals defined in Section 13. Base-mounted cabinets shall be mounted by means of studs set in the foundations. The mounting points shall be located inside the base-mounted cabinets.

9.1.4.11 Vents

In addition to the vents in the roof assembly, the cabinet shall have a vent or vents at or near the bottom to permit the intake of air. The size of the vents shall permit the flow of air corresponding to the rated flow of the fan. Vents shall not be smaller than 19,000 mm^2. The vents shall be equipped with standard-size, replaceable fiberglass filters. Vents shall not permit the entrance of rain or snow.

9.1.5 Finish

Unless otherwise noted, aluminum cabinets shall be unpainted natural aluminum. The aluminum shall be degreased and shall be free of scratches and blemishes.

9.1.6 Equipment Layout

All equipment and components shall be laid out for ease of use and servicing. It shall not be necessary to move or remove any equipment in order to view and operate the controls of any equipment. It shall not be necessary to remove any equipment or components in order to have access to other equipment or components for servicing. Exceptions to these requirements are that the fan, thermostat and side/back panels may require removal of shelf-mounted equipment to render them accessible. In these cases,

the equipment which must be removed shall require the use of only simple hand tools to accomplish the removal. To the extent practical, the layout of equipment and terminals within the various cabinets furnished shall be identical from cabinet to cabinet. The cabinet shall have a hinged, fold-down back panel to permit easy access to the rear terminals.

9.1.7 Lamp and Door Switch

The cabinet shall be equipped with two (2) 15-watt (minimum) fluorescent lamp assemblies, complete with lamps, located to illuminate the face of the equipment in the cabinet and the field terminals. The lamps shall be controlled by a door-actuated switch which turns the lamps on when the door is open and off when the door is closed. The lamp assemblies shall utilize standard lamps that are readily available from commercial lamp outlets.

9.1.8 Thermostat

The cabinet shall be equipped with an adjustable thermostat located in the upper portion and connected to control the fan. It shall be manually adjustable within the range of at least 26 to 77 °C and shall have a calibrated scale. The thermostat shall have contacts rated sufficiently for use with the fan. The thermostat shall turn the fan on at the set temperature and shall turn it off when the temperature is 2.5 degrees below the set temperature.

9.1.9 Electronic Noise Suppression

The cabinet shall have sufficient electrical and electronic noise suppression to enable all equipment in it to function properly. In addition, the cabinet shall be equipped with one or more radio interference filters connected between the stages of the power line surge protector. The filter(s) shall minimize interference generated in the cabinet in both the broadcast and aircraft frequencies. The filter(s) shall provide attenuation of at least 50 decibels over a frequency range of 200 kilohertz to 75 megahertz. Filters shall be hermetically sealed in metal cases and shall be insulated. The filter shall be rated at least at the rated current of the main circuit breaker, 125-volt, 60 Hertz.

9.1.10 Duplex Receptacle

The cabinet shall be equipped with a duplex receptacle located conveniently for service personnel and in such a position that no electrical hazard will be presented to such personnel when using the receptacle. The receptacle shall be of the 3-wire ground fault interrupt type that will also accept a standard 2-prong, non-grounding plug. The

receptacle shall be reserved for the use of service personnel. No normal control cabinet equipment shall be connected to the receptacle.

9.1.11 Electrical Service

A. The cabinet shall be equipped with a NEMA standard circuit breaker box having at least two (2) circuit breakers. Alternatively, the circuit breakers shall be installed in such a way that personnel servicing the cabinet, including the rear of the back panel, cannot inadvertently be exposed to hazard. A terminal block connected to the circuit breakers shall accommodate service wire as large as A.W.G. #6. These circuit breakers shall be in addition to any fuses which are a part of the individual control equipment components. See Figure 9.1, which supersedes Figure 10-4 in the NEMA Specifications.

B. The electrical service conductors shall be contained in a 25 mm flexible conduit as described in the National Electrical Code. This conduit shall enclose the service from the entrance conduit to the circuit breaker box or other suitable enclosure. It shall be long enough to be dressed neatly and attached to the cabinet walls. The conduit shall be equipped with a coupling to enable its attachment to the entrance conduit.

9.1.12 Bus Bars

9.1.12.1 Ground Bus

The cabinet shall have a ground bus having at least 20 terminals. The bus shall be attached and electrically bonded to the wall of the cabinet and located conveniently to the traffic signal load circuits. The terminals shall accommodate A.W.G. #10, #12 and #14 conductors. At least one (1) terminal on each end shall be grounded and shall accommodate an A.W.G. #4 conductor

9.1.12.2 AC Neutral Bus

The cabinet shall have an AC Neutral bus having at least 24 terminals. The bus shall be isolated electrically from the cabinet ground. The terminals shall accommodate A.W.G. #10, #12 and #14 conductors. The bus bar shall be conveniently located near the traffic signal load circuits.

9.1.12.3 Bonding Jumper

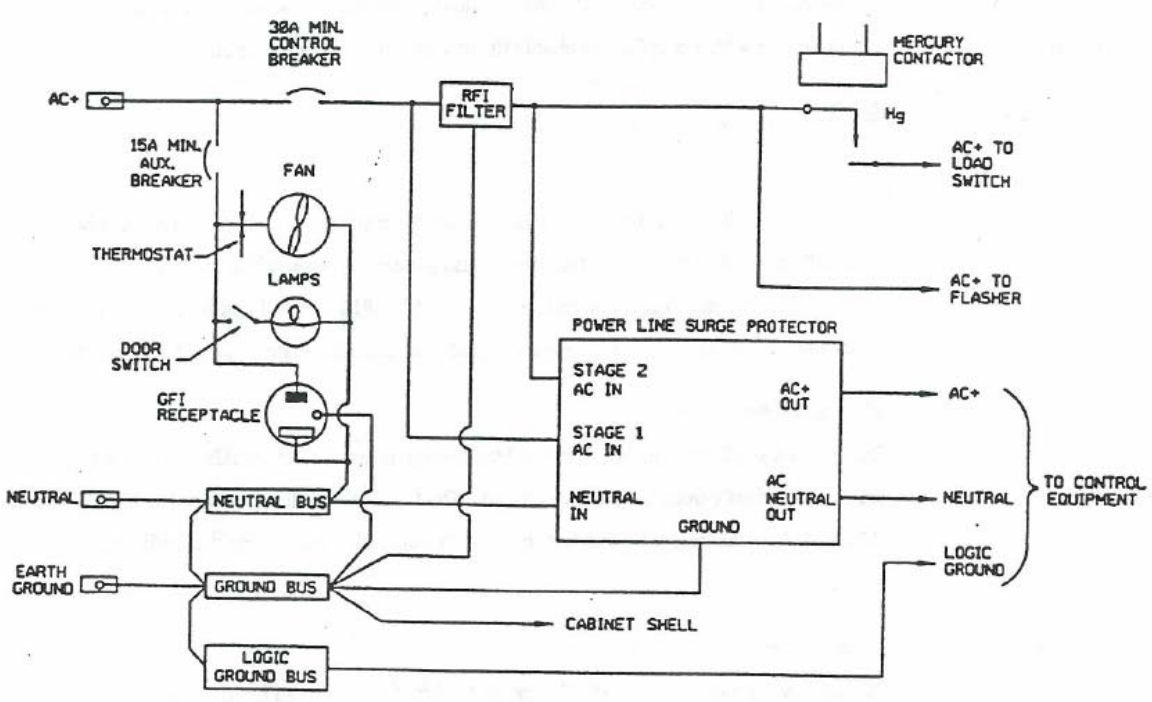
The bonding jumper between AC Neutral and cabinet ground shall be installed using A.W.G. #6 or larger copper wire. This jumper is shown in Figure 9.1. A label shall be

attached to this jumper with string tie. This label shall read:

> This Jumper and label shall be removed if AC Neutral is bonded to Ground in a service disconnect housing or meter base located ahead of this point in the service.

9.1.13 Surge Protection

The cabinet shall be equipped with surge protection devices to protect all of the equipment in the cabinet from damage due to lightning and external circuit power and current surges. As a minimum, the cabinet shall be furnished with the following surge protection devices which conform to the requirements of Section 6 of these *Specifications*.



Cabinet Power Distribution

Figure 9.1

9.1.13.1 Power Line Surge Protector

A power line surge protector (see Section 6) shall be furnished and installed in the power service as shown in Figure 9.1. The surge protector shall be installed in the circuit breaker box in a manner that will permit easy servicing. The surge protector shall be grounded and electrically bonded to the cabinet within 50 mm.

9.1.13.2 Loop Detector Surge Protectors

Loop detector surge protectors (see Section 6) shall be furnished and installed in cabinets which house loop type vehicle detectors as required by these *Specifications*, the plans or the bid list. A loop detector surge protector shall be used to protect each detector loop input to each loop type vehicle detector in the cabinet. The protectors shall be installed directly on the loop field terminals. The grounding conductor shall be as short and straight as possible. The grounding conductor shall provide grounding of each protector that is the electrical equivalent of an A.W.G. #6 (minimum) copper conductor.

9.1.13.3 Communications Surge Protectors

If the plans or the bid list require that the cabinet house a controller or communications equipment that is to be interconnected with other locations via telephone lines or paired-conductor interconnect cable and using multiplexed communications techniques, the cabinet shall be furnished with communications surge protectors (Type Q and Type SC as appropriate) conforming to the requirements of Section 6 of these *Specifications*. The cabinet shall contain a sufficient number of each type of communications surge protector to protect the equipment in the cabinet from surges which may be introduced from each communications pair that is actually connected to the equipment in the cabinet. A surge protector shall also be furnished for the voice communications circuit, if any. Surge protection is not required for communications pairs that are merely spliced in the cabinet with no connection to the equipment.

9.1.13.4 Signal Circuit Surge Protectors

All vehicular signal load circuits and all pedestrian signal load circuits shall have metal oxide varistors (V150LA20 or approved equivalent) connected to their load terminals to protect the load switches from surges on the signal cables.

9.1.14 Equipment Connection

9.1.14.2 It shall be possible to remove each item of equipment from the cabinet without disconnecting individual wires. The equipment shall either be connected to the cabinet by means of harnesses with suitable MS-type, or other multi-pin connectors, or be mounted in card racks that provide for automatic connection of the card when it is inserted in the rack. The connector of any harness carrying voltages in excess of 50 V shall be grounded, if metal.

9.1.14.3 Functionally equivalent equipment shall be electrically and mechanically

interchangeable.

9.1.14.4 All equipment and circuit cards shall be designed or keyed so that it shall be physically impossible to connect the unit to the wrong connector or insert it into an incorrect slot.

9.1.14.5 The cabinet shall be furnished with all necessary circuitry for connecting and interfacing all of the equipment which the cabinet is required to contain and to provide the operation required by the bid list or the plans.

9.1.15 Terminals

9.1.15.1 The cabinet shall be equipped with terminal blocks (strips) for the termination of all field conductors and all internal wires and harness conductors. All wires shall be terminated at terminals.

9.1.15.2 All field terminals shall be readily accessible without the removal of equipment and shall be located conveniently to the wires, cables and harnesses to be connected.

9.1.15.3 Each terminal block shall be of electrical grade thermoplastic or thermosetting plastic. Each terminal block shall be of closed back design and have recessed-screw terminals with molded barriers between the terminals.

9.1.15.4 Each terminal shall consist of two (2) terminal screws with a removable shorting bar between them; however, if the terminal block is part of a fabricated panel, each terminal may consist of a single terminal screw with a feed-through binding post to which conductors are soldered behind the panel.

9.1.15.5 Each terminal block shall be labeled with a block designation and each terminal shall be labeled with a number. All terminal functions shall also be labeled on the back panel or terminal blocks. All labels shall be visible when the terminal block is fully wired. The labels shall be shown on the cabinet wiring diagrams.

9.1.15.6 No terminals shall be closer than 100 mm to the bottom of the cabinet. Those in base-mounted cabinets shall be at least 150 mm from the bottom.

9.1.15.7 Terminals serving similar functions shall be grouped together.

9.1.15.8 No terminals shall be located on the under side of shelves or at other places where they are not readily visible and accessible or where they may be a hazard to personnel who might inadvertently touch them. The police panel, if required, shall have an enclosure over the terminals of its components to prevent hazard to personnel. Cardboard and other types of flexible covers shall not be acceptable.

9.1.16 Harnesses

9.1.16.1 All equipment in the cabinet shall be connected to the cabinet, to the other items of equipment and to the field circuits at the cabinet terminal blocks by means of neatly trained harnesses.

9.1.16.2 All functions on each utilized connector of each unit of equipment shall be connected to the cabinet terminal block even though some of the functions may not be used at the particular location.

9.1.16.3 Each harness which supplies power or an AC^{+} input greater than 24 volts shall contain a separate, secondary ground conductor of sufficient size to safely carry any fault current which its associated unit may develop.

9.1.16.4 Harness lengths specified elsewhere in these *Specifications* as part of the associated items of equipment are for raw harnesses. When these harnesses are installed in the cabinet, they may be shortened appropriately, provided that they shall remain long enough to allow their associated equipment units to be relocated in an upright position for servicing to the roof of the cabinet or to the ground at an elevation 305 mm below the cabinet.

9.1.16.5 All harnesses shall be neatly dressed along the cabinet walls either parallel to or perpendicular to the floor. They shall not run diagonally.

9.1.16.6 The harness connecting the components on the door to the remainder of the cabinet shall not touch the door jamb in any door position including fully open.

9.1.17 Wiring

9.1.17.1 Each conductor, including unused conductors, within or entering the cabinet shall be connected to a terminal. No more than two (2) conductors shall be connected to any single terminal screw. This provision does not apply to terminals on the load side of the load switches.

9.1.17.2 Each conductor shall have a crimped spade lug where connected to a terminal screw. Terminations to the back panel may be soldered. Terminators such as quick connectors and barrel connectors are not acceptable.

9.1.17.3 No in-line splices shall be permitted in any conductor. All connections shall be made at terminals.

9.1.17.4 The outgoing circuits shall be of the same polarity as the line side of the AC supply. The common return shall be of the same polarity as the grounded side of the AC supply.

9.1.17.5 All wiring shall be formed into neatly packaged and neatly dressed harnesses and shall be laced, braided or tied with nylon tie wraps at closely spaced intervals.

9.1.17.6 Where wires, cables or harnesses must be attached to the cabinet walls or door for support or to prevent undue wear or flexing, the attachment shall be made using nylon tie straps or metal clamps with rubber or neoprene insulators. These attachment devices shall be screwed to the cabinet. Stick-on clamps or straps shall not be permitted.

9.1.17.7 All field wiring and all internal conductors which are likely to be disconnected from time to time shall be tagged with non-fading, permanent sleeve labels at the ends of the conductors at the terminals. Sleeve labels shall be shrunk to tightly grip the conductors. Alternatively, internal conductors shall have their labels hot stamped on the insulation at intervals of no greater than 100 mm.

9.1.17.8 All jumpers shall be wire conductors or metal plates. The use of printed circuit back panels or back panels using wire tracks on boards shall not be permitted.

9.1.18 Prints and Holder

A 255 mm x 355 mm plastic envelope or container shall be furnished and installed in the cabinet for holding the cabinet wiring diagrams and equipment manuals. It shall be located so that it is convenient for service personnel. Two (2) sets of non-fading cabinet wiring diagrams shall be furnished in a paper envelope or container and placed in the plastic envelope or container.

9.2 CONTROLLER CABINETS

This article sets forth the requirements for controller cabinets as required by the bid list or the plans. Controller cabinets are control equipment cabinets to be used at intersections or mid-block pedestrian crossings to house controllers, conflict monitors, detectors, on-street masters and other items of equipment as required by the bid list or the plans. The following types of controller cabinets are covered in this article:

- Pretimed cabinets to house pretimed traffic signal controllers;
- Type 2 cabinets to house two-phase traffic signal controllers;
- Type 4 cabinets to house two-phase through four-phase traffic signal controllers;

and

- Type 8 cabinets to house two-phase through eight-phase traffic signal controllers.

As required by the plans or the bid list, controller cabinets shall also house on-street master controllers. Controller cabinets shall conform to the requirements of article 9.1 and to the following requirements as applicable.

9.2.1 Detector Terminals

Three (3) terminals (two (2) for loop conductors and one (1) for shield) shall be provided for each loop shown on the plans or required by the bid list. As a minimum, the cabinet shall provide sufficient terminals for four (4) loops and detectors in Type 2 cabinets, eight (8) loops and detectors in Type 4 cabinets, and sixteen (16) loops and detectors in Type 8 cabinets.

9.2.2 Flasher and Flashing Operation

9.2.2.1 The cabinet shall be furnished with one (1) or more solid state flashers conforming to the requirements of Section 7 of these *Specifications* to operate the signal displays when the intersection is operated in the flashing mode. If needed to handle the signal load without overloading the flasher, the cabinet shall be furnished with additional flashers.

9.2.2.2 The cabinet shall also be furnished with a flasher socket for each flasher. The sockets shall be a part of the cabinet back panel.

9.2.2.3 The cabinet shall be wired so that it shall be possible to select either flashing red or flashing yellow for each signal circuit by switching a jumper plug on the back panel or by switching jumpers using simple hand tools. Disassembly of and access to the rear of the back panel shall not be required to effect a flash color change. Movement of no more than three (3) jumpers shall be required to change the flash color for any signal circuit.

9.2.2.4 The cabinet shall be wired to effect the switch between normal stop-and-go operation and flashing operation. The flashing operation shall be as follows:

A. The controller shall control the planned change from stop-and-go operation to flashing operation.

B. Upon actuation of the emergency flash switch in the police panel or the technician flash switch in the test switch panel or upon command of the conflict monitor, the signal indications shall be disconnected from the load switches and the appropriate signal indications shall be connected to flashing power. All other signal indications shall be dark. This change shall take place immediately upon actuation regardless of the signal indications being displayed.

C. Regardless of the mode of entry into flashing operation, the return to normal stop-and-go operation shall occur only when the controller begins to time the major street WALK interval (green interval if WALK is not used). This shall be accomplished via the activation of the external start input.

D. The operation of the intersection controller shall not be affected when flashing operation is initiated by the technician flash switch or the communications unit, if any, and the controller shall continue to operate normally. However, when actuated by the emergency flash switch or the conflict monitor, the controller shall stop timing.

9.2.3 Test Switch Panel

The cabinet shall be furnished with a neatly labeled test switch panel mounted on the inside of the cabinet door. The panel shall contain the following components which shall be connected to provide the functions indicated.

9.2.3.1 Detector Circuit Test Switches

A. Each detector circuit test switch shall be a three (3) position (on-off-momentary on) switch. Each switch shall be connected to the controller's or communications unit's detector input and in parallel with its associated detector's output so that service personnel can place both momentary and constant calls on the device to be actuated. When off, the switch shall have no effect on the device to be actuated. In all cases, the detector shall remain connected to the device to be actuated.

B. A detector circuit test switch shall be provided and connected for each vehicle detector input to the controller and each pedestrian detector input to the controller regardless of how many of the controller's phases are in use. In addition, detector circuit test switches shall be provided and connected to the system detector inputs of the communications unit if required by the plans or the bid list. As a minimum, the following numbers of switches shall be provided.

Type of Cabinet	Vehicle Detector Switches	Pedestrian Detector Switches
Pretimed cabinet	0	0
Type 2 cabinet	2	2
Type 4 cabinet	4	4
Type 8 cabinet	8	4

9.2.3.2 Technician Flash Switch

The test switch panel shall contain a toggle switch for switching the intersection operation between normal stop-and-go (AUTO) operation and flashing (see paragraph 9.2.2) operation.

9.2.3.3 Controller Power Switch

The test switch panel shall contain a toggle switch connected to remove power from the controller and all auxiliary equipment but it shall not interrupt power to the flasher.

9.2.3.4 Preemption Test Switches

The cabinet shall contain a preemption test switch for each distinct preemption operation required by the plans or the bid list.

9.2.4 Police Panel

The cabinet shall have a police panel which shall be furnished with the indicated components connected to accomplish the functions indicated.

9.2.4.1 Police Panel Construction

The police panel shall be furnished in the main door and it shall have a door on it. The police panel door shall permit access to the police panel when the main door is closed. Even with the police panel door open, no rainwater shall enter the cabinet. The door shall be hinged on the right side as viewed from the front. The police panel door shall have a lock which is keyed to a standard police/fire call box key. At least two (2) keys shall be furnished with each cabinet. The grip of each key shall have an area of at least 500 mm^2.

9.2.4.2 Emergency Flash Switch

The police panel shall contain a toggle switch for switching the intersection operation between normal stop-and-go (AUTO) operation and flashing (see paragraph 9.2.2) operation.

9.2.4.3 Signal Switch

The police panel shall contain a toggle switch connected to permit power to the field signal indications to be turned off and on. When in the off position, power shall be removed from the field signal indications but the controller and all equipment in the cabinet shall continue to operate normally.

9.2.4.4 Automatic/Manual Switch

The police panel shall contain a toggle switch connected to switch the intersection operation between normal stop-and-go operation (AUTO) and manual operation (MANUAL) using a hand control. Manual control shall be implemented using only the Manual Control Enable and Interval Advance functions of the controller.

9.2.4.5 Hand Control

A. The police panel shall contain a 6.35 mm locking phone jack for a hand control to effect manual control of the intersection as described above. The police panel shall also have sufficient room for storage of the hand control and its cord.

B. A hand control shall be furnished with each cabinet if specifically required by the plans or the bid list. The hand control shall be a standard traffic signal manual control push-button located on one end of a 3 m coil cord, with a suitable locking plug on the other end. The plug and jack shall lock together so that they will not disconnect even when the cord is stretched to its limit.

9.2.5 Preemption

9.2.5.1 For cabinets where the bid list or the plans require preemption of the normal signal sequence, the cabinet shall be fully wired to support the preemption functions of the controller. Preemption shall be provided by the controller and external preemptors are not acceptable.

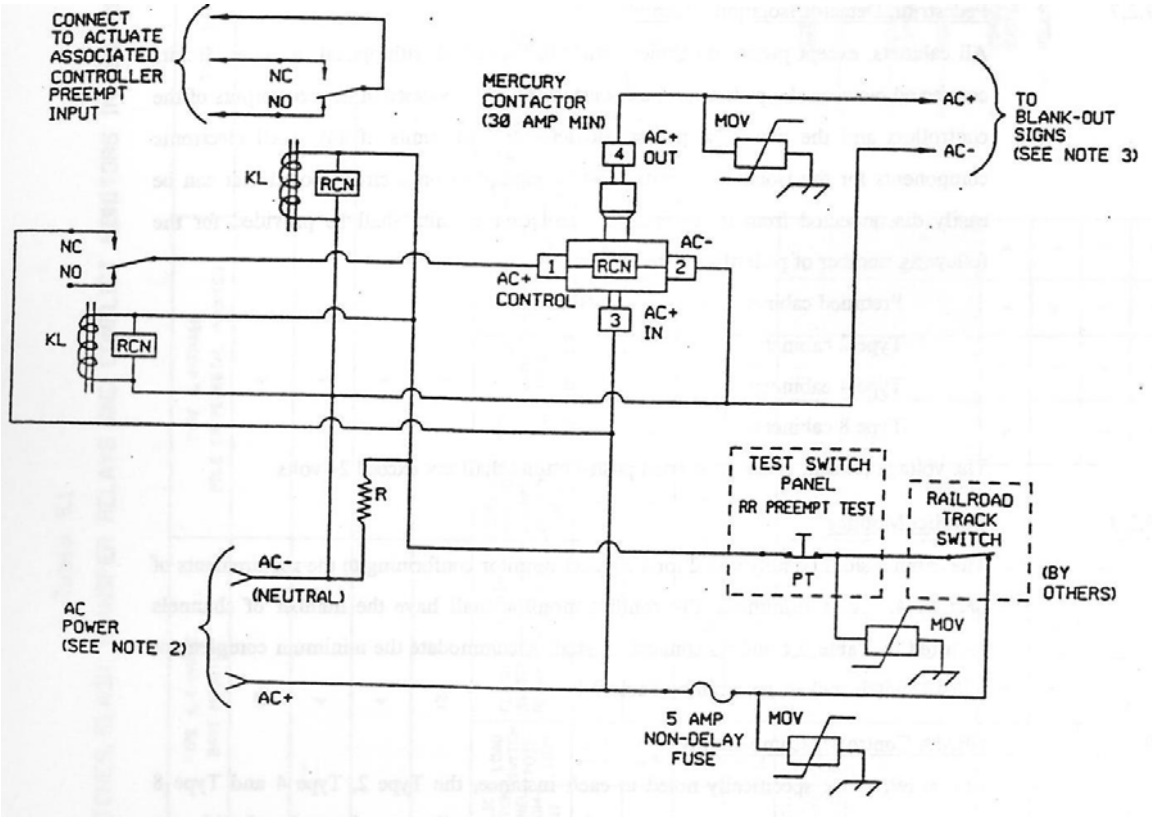
9.2.5.2 If railroad preemption is required by the plans or the bid list, the cabinet shall be furnished with the circuitry shown in Figure 9.2 to provide control of associated blank-out signs even with the controller removed.

9.2.6 Load Switches

9.2.6.1 The cabinet shall be furnished with load switch sockets to accommodate load switches which conform to the requirements of Section 7 of these *Specifications*. The number of load switch sockets provided shall be sufficient to provide the operation required in the bid list or the plans. As a minimum, the cabinets shall have the number of sockets required by Table 9.1. The sockets shall be located in the load bay in phase number order and in overlap order. Overlap load switch sockets shall be located between those for the prime phases and the pedestrian signals.

9.2.6.2 The cabinet shall be furnished with load switches which conform to the requirements of Section 7 of these *Specifications*. The number of load switches provided shall be

sufficient to provide the operation required in the bid list or the plans. As a minimum, the cabinets shall have the number of load switches required by Table 9.1.



NOTES:

1. Values of components shall be ıined by cabinet manufacturer to satisfy specific ıation.
2. Connect AC power to output of RFI hown in Figure 9.1.
3. Terminals shall be provided for at wo blank-out signs.

KL	Single-Pole, Double-Throw Plug-In Relay
R	1.5 kΩ, 25 W Drain Resistor
RCN	Resistor Capacitor Network for Filtering
PT	Normally-Closed Push-Button Switch
MOV	Metal Oxide Varistor

Railroad Preemption and Blank-Out Sign Control Circuitry
Figure 9.2

9.2.6.3 All load switch sockets shall be sturdy so that they will not crack due to careless insertion or removal of the load switches.

9.2.7 Pedestrian Detector Isolation Assembly

All cabinets, except pretimed cabinets, shall be furnished with optical isolation circuits connected between the pedestrian push-buttons and the pedestrian detector inputs of the controllers and the two-pulse pedestrian detector logic units, if any. All electronic components for the isolation circuits shall be contained on a circuit board that can be easily disconnected from its receptacle. Isolation circuits shall be provided for the following number of pedestrian detector circuits:

Pretimed cabinet:	None
Type 2 cabinet:	2
Type 4 cabinets:	4
Type 8 cabinets:	4

The voltage present at the pedestrian push-buttons shall not exceed 24 volts.

9.2.8 Conflict Monitor

The cabinet shall be fully wired for a conflict monitor conforming to the requirements of Section 4. As a minimum, the conflict monitor shall have the number of channels required by Table 9.1 and its connection shall accommodate the minimum complement of load switch sockets required by Table 9.1.

9.2.9 NEMA Controller Compatibility

Unless otherwise specifically noted in each instance, the Type 2, Type 4 and Type 8 cabinets shall be wired in such a way that the controller may be replaced with any controller, regardless of manufacturer, that conforms to the requirements of the NEMA Specifications without the need for cabinet modifications and without any loss of function. An exception to this requirement is cabinets for intersections with preemption.

9.3 ON-STREET MASTER CABINETS

This article sets forth the requirements for on-street master cabinets as required by the bid list or the plans. On-street master cabinets are control equipment cabinets to be used to house closed-loop system on-street masters, detectors and other items of equipment as required by the bid list or the plans. On-street master cabinets shall conform to the requirements of Article 9.1 and to the following requirements as applicable.

Table 9.1

MINIMUM REQUIREMENTS FOR LOAD SWITCHES, FLASH TRANSFER RELAYS AND CONFLICT MONITORS IN CONTROLLER CABINETS

CABINET TYPE	TYPE 8					TYPE 4, 4-PHASE BASE MOUNTED					TYPE 4, 4-PHASE POLE OR PEDESTAL MOUNTED					TYPE 2					PRETIMED
NUMBER OF LOAD SWITCH SOCKETS	16					12					8					4					8
NUMBER OF LOAD SWITCHES	8					4					4					2					2
NUMBER OF FLASH TRANSFER RELAYS	6					4					4					1					1
SIZE OF CONFLICT MONITOR (CHANNELS)	12					12					12					3					12
NEMA PHASE OR OVERLAP	CONFLICT MONITOR CHANNEL ASSIGNMENT	LOAD SWITCH POSITION	FLASH TRANSFER RELAY	FLASH COLOR	FLASH CIRCUIT	CONFLICT MONITOR CHANNEL ASSIGNMENT	LOAD SWITCH POSITION	FLASH TRANSFER RELAY	FLASH COLOR	FLASH CIRCUIT	CONFLICT MONITOR CHANNEL ASSIGNMENT	LOAD SWITCH POSITION	FLASH TRANSFER RELAY	FLASH COLOR	FLASH CIRCUIT	CONFLICT MONITOR CHANNEL ASSIGNMENT	LOAD SWITCH POSITION	FLASH TRANSFER RELAY	FLASH COLOR	FLASH CIRCUIT	
1	1	1	1	R	1	1 1	1 V 9 P	1	R D	1	1	1	1	R	1	1 1	1 V 3 P	1	R D	1	
2	2 2	2 V 13 P	1	Y D	2	2 2	2 V 10 P	1	Y D	2	2	2	1	Y	2	2 2	2 V 4 P	1	Y D	2	
3	3	3	2	R	1	3 3	3 V 11 P	2	R D	1	3	3	2	R	1						
4	4 4	4 V 14 P	2	R D	2	4 4	4 V 12 P	2	R D	2	4	4	2	R	2						
5	5	5	3	R	2																
6	6 6	6 V 15 P	3	Y D	1																
7	7	7	4	R	2																
8	8 8	8 V 16 P	4	R D	1																
A	9	9	5	R	1	5	5	3	Y	1	5	5	3	Y	1						
B	10	10	5	R	1	6	6	3	R	1	6	6	3	R	1						
C	11	11	6	R	2	7	7	4	R	2	7	7	4	R	2						
D	12	12	6	R	2	8	8	4	R	2	8	8	4	R	2						

LEGEND

D — DARK

P — PEDESTRIAN LOAD SWITCH POSITION

R — RED

V — VEHICULAR LOAD SWITCH POSITION

Y — YELLOW

9.3.1 Shelf

Unless more shelves are required to accommodate the equipment to be housed, only two (2) shelves are required.

9.3.2 Detector Terminals

Three (3) terminals (two (2) for loop conductors and one (1) for shield) shall be provided for each loop, if any, shown on the plans or required by the bid list to be connected to the cabinet.

9.3.3 Test Switch Panel

The cabinet shall be furnished with a neatly labeled test switch panel mounted on the inside of the cabinet door. The panel shall contain a detector circuit test switch connected to each detector input of any device in the cabinet to which the plans or the bid list require detectors to be connected. Each detector circuit test switch shall be a three (3) position (on-off-momentary on) switch. The switch shall be connected in parallel with its associated detector's output so that service personnel can place both momentary and constant calls on the device to be actuated. When off, the switch shall have no effect on the device to be actuated. In all cases, the detector shall remain connected to the device to be actuated.

9.3.4 Police Panel

No police panel is required.

9.4 REMOTE DETECTOR CABINETS

This article sets forth the requirements for remote detector cabinets as required by the bid list or the plans. Remote detector cabinets are control equipment cabinets which house loop-type vehicle detectors which must be located remotely from a controller cabinet. Two (2) types of remote detector cabinets are specified herein; slave remote detector cabinets for use when the cabinet can be connected to the controller cabinet and stand-alone remote detector cabinets for use when the cabinet must be connected to a traffic signal system via a paired-conductor interconnect cable. Except as otherwise noted, the remote detector cabinets shall conform to the requirements of Article 9.1 and to the following requirements:

9.4.1 Slave Remote Detector Cabinets

Slave remote detector cabinets are intended to be connected to the associated controller cabinet by a 3-conductor (minimum) signal cable and a 6-pair (minimum) interconnect cable. They shall conform to the following requirements.

9.4.1.1 The minimum size of a slave remote detector cabinet shall be 69,000 cm^3 of usable space. The cabinet shall have unobstructed shelf space to accommodate a future unit that is 355 mm x 355 mm x 255 mm.

9.4.1.2 Only one (1) shelf is required.

9.4.1.3 The cabinets shall accommodate six (6) Type 1 loop-type vehicle detectors.

9.4.1.4 Three (3) terminals (two (2) for loop conductors and one (1) for shield) shall be provided for each of six (6) loops.

9.4.1.5 Twenty (20) terminals shall be provided for the connection of the signal cable from the associated controller cabinet. They shall have the following functions.

- AC Power
- Secondary ground (cabinet and earth)
- Channel 1 common
- Channel 2 common
- Channel 3 common
- Channel 4 common
- Channel 5 common
- Channel 6 common
- AC Common (neutral)
- Channel 1 output
- Channel 2 output
- Channel 3 output
- Channel 4 output
- Channel 5 output
- Channel 6 output
- 5 spare terminals

9.4.1.6 No flexible electrical service conduit shall be provided inside the cabinet. The main circuit breaker input shall be connected to the AC terminals required in paragraph 9.4.1.5.

9.4.1.7 Ground Bus

The cabinet shall have a ground bus having at least 10 terminals. The bus shall be attached and electrically bonded to the wall of the cabinet and located conveniently to the traffic signal load circuits. The terminals shall accommodate A.W.G. #10, #12 and #14 conductors. At least one (1) terminal on each end shall be grounded and shall accommodate an A.W.G. #4 conductor.

9.4.1.8 AC Neutral Bus

The cabinet shall have an AC Neutral bus having at least 12 terminals. The bus shall be isolated electrically from the cabinet ground. The terminals shall accommodate A.W.G. #10, #12 and #14 conductors. The bus bar shall be conveniently located near the detector harness connections.

9.4.1.9 Bonding Jumper

The bonding jumper between AC Neutral and cabinet ground shall be installed using A.W.G. #6 or larger copper wire. This jumper is shown in Figure 9.1. A label shall be attached to this jumper with string tie. This label shall read:

> This Jumper and label shall be removed if AC Neutral is bonded to Ground in a service disconnect housing or meter base located ahead of this point in the service.

9.4.1.10 No light is required.

9.4.2 Stand-Alone Remote Detector Cabinets

Stand-alone remote detector cabinets are intended to be connected to a traffic signal system by a paired-conductor interconnect cable. They shall conform to the following requirements.

9.4.2.1 The minimum size of a stand-alone remote detector cabinet shall be 69,000 cm^3 of usable space. The cabinet shall have unobstructed shelf space to accommodate a future unit that is 355 mm x 355 mm x 255 mm.

9.4.2.2 Only one (1) shelf is required.

9.4.2.3 Three (3) terminals (two (2) for loop conductors and one (1) for shield) shall be provided for each of six (6) loops.

9.4.2.4 Ground Bus

The cabinet shall have a ground bus having at least 10 terminals. The bus shall be attached and electrically bonded to the wall of the cabinet and located conveniently to the traffic signal load circuits. The terminals shall accommodate A.W.G. #10, #12 and #14 conductors. At least one (1) terminal on each end shall be grounded and shall accommodate an A.W.G. #6 conductor.

9.4.2.5 AC Neutral Bus

The cabinet shall have an AC Neutral bus having at least 12 terminals. The bus shall be isolated electrically from the cabinet ground. The terminals shall accommodate A.W.G. #10, #12 and #14 conductors. The bus bar shall be conveniently located near the detector harness connections.

9.4.2.6 Bonding Jumper

The bonding jumper between AC Neutral and cabinet ground shall be installed using A.W.G. #6 or larger copper wire. This jumper is shown in Figure 9.1. A label shall be attached to this jumper with string tie. This label shall read:

> This Jumper and label shall be removed if AC Neutral is bonded to Ground in a service disconnect housing or meter base located ahead of this point in the service.

9.4.2.7 No light is required.

SECTION 10
BEACON CONTROLLER ASSEMBLIES

This section of the *Specifications* sets forth the requirements for beacon controller assemblies. Three (3) types of beacon controller assemblies are described herein as follows:

Type F1 - The beacon controller assembly consists of a cabinet, dual-circuit flasher, specified electronics, and 20 Amp circuit breaker. This cabinet has no minimum size requirement.

Type F2 - The beacon controller assembly consists of a cabinet, dual-circuit flasher, specified electronics and a 20 Amp circuit breaker. The minimum size requirement for this cabinet shall be 500 mm high, 400 mm wide and 300 mm deep.

Type F3 - The beacon controller assembly consists of a cabinet, dual-circuit flasher, specified electronics, circuit breakers, a fan and thermostat and a cabinet light. The minimum size requirement for this cabinet shall be 1000 mm high, 560 mm wide, and 375 mm deep.

All beacon controller cabinets shall conform to the following requirements unless otherwise noted.

10.1 SUBMITTAL REQUIREMENTS.

Drawings showing dimensions, location of required equipment and mechanisms, cabinet electrical diagrams, part numbers and descriptions of required equipment and accessories shall be submitted to the Engineer. Certification that materials used in the construction of the cabinet meets these specifications shall be submitted to the Engineer.

10.2 PHYSICAL REQUIREMENTS.

10.2.1 Cabinet shell requirements shall conform to the requirements of Section 9.1.4 of these *Specifications.*

10.2.2 The cabinet(s) shall have a vent or vents at or near the bottom to permit the intake of air. On the F1 and F2 cabinets, there shall be a single vent on each side of the cabinet at the bottom in order to facilitate air flow. On the F3 cabinet, the size of the vents shall permit the flow of air corresponding to the rated flow of the fan.

Vents shall not be smaller than 12900 mm^2. The vents shall be equipped with standard-size, replaceable filters or permanent filters if located where they can easily be cleaned.

10.2.3 The cabinet (F3 only) shall be equipped with two NEMA standard circuit breakers (20A & 15A). Alternatively, the circuit breakers shall be installed in such a way that personnel servicing the cabinet, including the rear of the back panel, cannot inadvertently be exposed to hazard. A terminal block connected to the circuit breaker shall accommodate service wire as large as A.W.G. #4. The circuit breakers shall be in addition to any fuses which are a part of the individual control equipment components.

10.2.4 All cabinets shall have sufficient electrical and electronic noise suppression to enable all equipment in it to function properly. In addition, the cabinets shall be equipped with a radio interference filter connected between the stages of the power line surge protector. The filter shall minimize interference generated in the cabinets in both the broadcast and aircraft frequencies. The filter shall provide attenuation of at least 50 decibels over a frequency range of 200 kilohertz to 75 megahertz. The filter shall be hermetically sealed in metal cases and shall be insulated. The filter shall be designed to operate in a 125-volt, 60 Hertz, single phase circuit with currents of 15 amperes or more.

10.2.5 Surge Protection (F2 & F3):

A power line surge protector per Section 9.1.13 shall be furnished and installed in the power service. The surge protector shall be installed in the circuit breaker enclosure in a manner that will permit easy servicing. The surge protector shall be grounded and electrically bonded to the cabinet within 100 mm. Metal oxide varistors, type V150LA20, shall be connected between each field terminal and the ground bus on all three cabinet types. Filtered power shall feed the time switches in F2 cabinets and the detector panel in F3 cabinets.

10.2.6 Terminals shall be installed within the cabinets in conformance with the requirements of Section 9.1.15 of these *Specifications*.

10.2.7 Wiring:

(1) Each conductor, including unused conductors, within or entering the cabinet shall be connected to a terminal. No more than two conductors shall be connected to any single terminal screw.

(2) Each conductor shall have a crimped spade lug where connected to a terminal screw. Terminations to the back panel may be soldered. Terminators such as quick connectors and barrel connectors are not acceptable.

(3) No in-line splices shall be permitted in any conductor inside the controller cabinet. All connections shall be made at terminals.

(4) The outgoing circuits shall be of the same polarity as the line side of the power supply. The common return shall be of the same polarity as the grounded conductor (neutral) of the power supply.

(5) All wiring shall be formed into neatly packaged and neatly dressed harnesses and shall be laced, braided or tied with nylon tie wraps at closely spaced intervals.

(6) Where wires, cables or harnesses must be attached to the cabinet walls for support, or to prevent undue wear or flexing, the attachment shall be made using nylon tie straps or metal clamps with rubber or neoprene insulators. These attachment devices shall be screwed to the cabinet. Stick-on clamps or straps shall not be permitted.

(7) AC+, AC-, chassis ground and flasher circuit conductors shall be tagged with non-fading, permanent sleeve labels at the ends of the conductors at the terminals or be color coded. Sleeve labels shall tightly grip the conductors. Alternatively, internal conductors shall have their labels hot stamped on the insulation at intervals of no greater than 100mm. Label legends shall be permanent.

(8) All jumpers shall be wire conductors or metal plates. The use of printed circuit backpanels or back panels using wire tracks on boards shall not be permitted.

10.2.8 Equipment Layout:

All equipment and components shall be laid out for ease of use and servicing. It shall not be necessary to move or remove any equipment in order to view and operate the controls of any equipment. It shall not be necessary to remove any equipment or components in order to have access to other equipment or components for servicing. Two (2) exceptions to these requirements are that the fan and the thermostat may require removal of equipment to render them accessible. In these cases, the equipment which must be removed shall require the use of only simple hand tools to accomplish the removal. The layout of equipment and terminals within the various cabinets furnished shall be identical from cabinet to cabinet, unless otherwise approved by theCity.

10.2.9 Equipment Connection:

(1) It shall be possible to remove each shelf-mounted item of equipment from the cabinet without disconnecting individual wires. The equipment shall either be connected to the cabinet by means of harnesses with suitable multipin (or similar) connectors or be mounted in card racks that provide for automatic connection of the card when it is inserted in the rack.

(2) Functionally equivalent equipment shall be electrically and mechanically interchangeable.

(3) All equipment and circuit cards shall be designed or keyed so that it shall be physically impossible to connect the unit to the wrong connector or insert it into an incorrect slot.

(4) The cabinet shall be furnished with all necessary circuitry for connecting and interfacing all of the equipment which is to be furnished with the cabinet and to provide the operation required by the bid list or the plans.

(5) Type F3 cabinets shall be equipped with a minimum of 20 spare terminals.

(6) Type F3 cabinets shall be equipped with three (3) terminals (two (2) for loop conductors and one (1) for shield) for each loop for a minimum of eight (8) loop

circuits. A loop detector surge protector shall be connected to each detector loop input.

10.2.10 Prints and Holder (Does not apply to F1):

A suitably sized plastic envelope or container shall be furnished and installed in the cabinet for holding the cabinet wiring diagrams and equipment manuals. It shall be located so that it is convenient for service personnel. Two (2) sets of non-fading cabinet wiring diagrams shall be furnished in a paper envelope or container and placed in the plastic envelop or container.

10.3 REQUIRED CONTROL EQUIPMENT.

The following control equipment shall be furnished as part of the beacon controller assembly:

10.3.1 The cabinet shall be furnished with a solid state flasher meeting the requirements of Section 7.4. The flasher shall be connected to provide the beacon operation designated by the plans or the bid list.

10.3.2 If required by the plans or the bid list, each Type F2 cabinet shall be furnished with a solid state time switch meeting the requirements of Section 7.2. The time switch shall be connected to control the operation of the flasher. The time switch and the flasher shall be connected to provide the beacon operation designated by the plans or the bid list.

SECTION 11

CLOSED-LOOP TRAFFIC SIGNAL SYSTEM

This section sets forth the requirements for equipment and software used in closed loop systems comprised of interconnected TS-1 and TS-2 actuated traffic signal controllers. This section contains requirements which supersede the NEMA Specifications. The requirements of Section 1 of these *Specifications* apply to closed-loop systems.

11.1 GENERAL REQUIREMENTS.

11.1.1 All equipment furnished under this section shall be new including controllers, closed loop masters, auxiliary equipment, communications equipment, cabinets, conflict monitors, MMU's, cabinet accessory equipment, and system central equipment.

11.1.2 All controllers, accessory equipment, and cabinets furnished shall meet the requirements of the applicable portions of NEMA Standards Publication No. TS1-1989, or No. TS2-1992, Traffic Controller Assemblies published by the National Electrical Manufacturers Association, as called for in other sections of these Specifications, including those for cabinets, and accessories and the NEMA TS1-1989 or NEMA TS-2-1992 specifications for controllers, cabinets, and accessories. Also, the equipment shall meet any additional requirements cited in the applicable sections of these *Specifications* for traffic signal controllers, auxiliary and accessory equipment, conflict monitors, cabinets, and any other item cited in the various Sections of these *Specifications* which is used in the closed loop system.

11.1.3 In addition to the above requirements, the controllers, cabinets, and accessories shall be furnished with all circuitry and software needed to perform all functions required by this section unless otherwise specified in the bid document, plans, special provisions, or purchase order.

11.1.4 Any personal computer traffic signal system software necessary for operations required by this section shall be furnished to the City. The software shall be licensed for use by City personnel and by personnel of any other agency responsible for maintaining or operating the signal system equipment to use in the course of maintaining or operating the signal system and its various component equipment. The City shall be licensed to duplicate and distribute the software as necessary for

design and maintenance support.

11.1.5 Year 2000 compliance: All software shall perform fault-free in the processing of date and date-related data (including, but not limited to, calculating, comparing, sequencing, and logging) by all hardware, telecommunications, and software products required by these *Specifications*, individually and in combination. Fault-free performance includes the manipulation of this data with dates prior to, through and beyond January 1, 2000, and shall be transparent to the user.

Hardware, telecommunications and software products, individually and in combination shall successfully transition into the year 2000 with the correct date, without human intervention, including leap year calculations. Hardware and software products, individually and in combination, shall also provide correct results when moving forward or backwards in time across the year 2000.

11.1.6 All electronic components used in the conflict monitor shall be commercially available components which may be supplied by electronics supply houses. No proprietary components shall be used in the conflict monitors.

Exception: The City may permit, at its discretion, equipment with proprietary components to be supplied if the manufacturer agrees to supply the proprietary components to the City for repair purposes for a minimum period of five years. If the components are no longer available during this period, the manufacturer shall replace or otherwise repair any unit in which the component fails during that period at the price of the discontinued component.

11.1.7 The decision to perform warranty work by the City of Charlotte electronics technicians or to have warranty work performed by the vendor shall be at the discretion of the City. Bench repair training on the manufacturer's equipment shall be provided as required by the bid document or plans at no additional cost to the City unless otherwise specified. In addition to any formal training requirements, the manufacturer shall agree to provide the following upon request: 1) Prompt technical support to the City repair personnel during the contract and for a period of one year after the end of the warranty period at no cost to the City 2) Parts shall be supplied by the vendor to the City for all warranty repairs at no cost to the City (defective parts replaced under warranty by the Electronic Systems Lab will be

returned to the vendor for examination at the vendor's request). 3) Schematics and other documentation required to perform bench repair shall be sent to the Electronic Systems Lab within two weeks of request. Upon request from the vendor, the City agrees not to divulge any proprietary information contained in those documents.

At the request of the City , the vendor shall perform warranty repairs to equipment which fails during the warranty period at no cost to the City including freight costs to ship repaired equipment back to the City. The City shall pay freight charges to ship equipment to the vendor or manufacturer. All equipment shall be repaired and returned to the City within twenty-one (21) calendar days of receipt by the manufacturer.

11.1.8 Identification of Unit: The manufacturer's name, model number, serial number, and any other information necessary for proper identification shall be permanently inscribed on each piece of equipment covered by this section of the Specifications.

11.2 STRUCTURE OF THE SYSTEM.

11.2.1 Overall Structure: The system shall have essentially three (3) levels of control and interface: office, on-street master, and intersection. At the office level there shall be two (2) possible office sites as defined by the plans: a control center and a signal shop. Each site shall have a microcomputer with various peripheral equipment and identical software. Each on-street master shall be contained in the same cabinet as one (1) of the intersection controllers in its group, unless otherwise noted, and shall supervise the operation of one group of a minimum of 24 intersections. Each intersection shall have a conventional traffic signal controller and cabinet with various ancillary equipment as defined in other sections of these Specifications. The system shall operate properly, including traffic-responsive operation and time-of-week/time-of-day operation, in the absence of the microcomputers, except that transfer of information between the microcomputers and the on-street masters shall not be possible. Control center/signal shop functions which depend on this transfer shall not be provided in such circumstances.

11.2.2 Communications Structure:

(A) Central to Master: Both microcomputers shall communicate with the on-street

masters via the commercial, dial-up telephone network unless otherwise specified. Operator-definable telephone numbers of up to fourteen (14) digits with up to two (2) intermediate pauses shall be accommodated. The standard interface shall be a Hayes compatible smart modem at each microcomputer station and at the master cabinet.

(B) Central to Intersections: The microcomputers shall communicate with the intersection controllers and other intersection equipment through on-street masters. The system shall provide standard two-way system communications via the specified media with appropriate interface hardware.

The microcomputers, the on-street masters and the intersection controllers shall be furnished with all necessary modems, serial ports and telemetry to enable all required communications. Controllers shall have internal telemetry to interface them to the on-street masters via the interconnect cable and local modem device.

11.3 TRAFFIC FUNCTIONS.

The manufacturer's closed-loop traffic signal system with all of its components shall conform to the following functional requirements.

11.3.1 Number of Timing Plans: An intersection timing plan is defined as a unique combination of cycle length, split and offset at an intersection. The system may utilize either discrete timing plans or constructed timing plans. If discrete timing plans are used, at least sixteen (16) independent cycle lengths per group (subsystem) shall be provided, each with its own split and three offsets. If constructed timing plans are used, at least five (5) active cycle lengths per group shall be provided, each with at least three (3) offsets and three (3) splits (Thus, each intersection shall have a total of at least 45 constructed intersection timing plans available.). In addition, the system shall provide a means to select both flashing and free operation of the intersections on an on-street master basis.

11.3.2 Functions Related to Timing Plans: The following functions shall be related to the specific intersection timing plans and shall be implemented in the correct state as part of the associated timing plan. It shall not be necessary to use a special

scheduler entry to implement any of these functions. These functions shall be implemented by the unique combinations of cycle number, offset number and split number, if timing plan construction is used, or by the timing plan number, if discrete timing plans are used. The functions are:

- Alternate sequence operation
- Primary coordinated phases
- Minimum recall by phase
- Maximum recall by phase
- Pedestrian recall by phase
- Phase omit by phase

11.3.3 Number of On-Street Masters: Unless otherwise noted, the system shall support at least sixteen (16) on-street masters without hardware or software additions to the microcomputers even if a fewer number of on-street masters are to be implemented as part of this project. No modifications to the system program software shall be required to accomplish full expansion of the system.

11.3.4 Number of Groups and Intersections Per On-Street Master: Each on-street master shall support at least one (1) group of at least 24 intersections. If the on-street master will support more than one (1) group of intersections, at least one (1) of the groups shall support up to at least 24 intersections.

11.3.5 Timing Plan and Scheduler Resolution: Cycle lengths shall be adjustable in one-second increments. Offsets and splits shall be adjustable in 1-second increments or in percents of the cycle lengths. Events in the scheduler (both turn-on and turn-off) shall be adjustable in 1-minute increments.

11.3.6 Local Zero Reference for Timing Plans: The system shall enable the user to enter actual offset from the group's zero reference to the planned beginning of the primary coordinated phase green. It shall not be necessary to calculate adjustments in the yield points for varying amounts of pedestrian clearance times. Similarly, the system shall enable the user to enter the actual phase (green plus yellow plus second clearance) splits. It shall not be necessary to calculate fictitious splits. All adjustments required by the system for its operation shall be calculated and implemented by the system.

11.3.7 Intersection Operations Accommodated: The system shall accommodate and

properly control all of the intersection sequences required of actuated controllers in these *Specifications* including dual quad operation, sequential operation, quad sequential operation, and lead-lag operation.

11.3.8 Cross-Street Coordination: The system shall provide coordination of traffic on crossing streets as follows.

1. It shall be possible for the operator to select a secondary coordinated phase (phase pair in dual-ring controllers) for the intersection. When so selected, the system shall not permit termination of the secondary coordinated phase or phase pair until the planned (force-off) point in the cycle, even if traffic on the secondary coordinated phase is light.

2. Crossing artery control shall be provided for coordinated traffic flow through the common intersection of two (2) streets controlled by different on-street masters when the timing plans commanded by both field masters have the same cycle length and the on-street masters are linked together via a dedicated communications link. Crossing arterial control shall be in effect as long as both arterial cycle lengths are the same and shall remain in effect for a user-definable minimum period of 0 to 30 cycles or 0 to 60 minutes under traffic-responsive operation.

11.3.9 Double-Cycling: The system shall permit the operation of some signals in a group at one-half the cycle length of other signals in the group. The intersections operating on both cycle lengths shall share a common reference so that coordination can be maintained.

11.3.10 Traffic-Responsive Operation: The system shall be provided with a traffic-responsive mode of operation. The software providing traffic-responsive operation shall be resident in the master controller and shall provide the features outlined below.

A. General - Plan selection during traffic-responsive operation shall be based on user-selectable volume and occupancy data from the system detectors. Plan selection shall consider, at a minimum, the following traffic parameters:

a. Arterial traffic volume level;

b. Arterial traffic occupancy level;

c. Side street traffic volume level;

d. Side street traffic occupancy level.

B. Weighted traffic parameters - The system shall compute weighted traffic parameters using system detector data from a minimum of sixteen (16) system detectors, whose data is modified by user selected weights. The computed parameters used by the system shall indicate the traffic levels outlined in subparagraph A. A smoothing algorithm employing a user selectable smoothing factor shall be used to minimize the effects of spurious traffic changes.

C. Selection of cycle length, offset, and split - The system shall compare the weighted traffic parameters with user programmed parameters and select the desired combination of cycle length, split, and offset (plan number).

D. Cycle length, split, and offset (plan number) selection hysteresis - The system shall provide a user adjustable method to prevent rapid multiple plan changes from occurring due to variance of parameters near plan transfer points.

E. Priority of mode - Time-of-week/time-of-day operation shall take precedence over traffic-responsive operation.

F. The system shall permit the use of any or all system detectors as desired in the computation of parameters used to select cycle length, split, and offset.

G. If a system detector is used for the computation of more than one (1) parameter, the system shall permit use of a separate weighting factor in the computation of each parameter.

H. System detector failure adjustment - System detectors determined to be failed shall be removed from use in the computation of traffic parameters and the selection of cycle length, split, and offset. Upon resumption of satisfactory operation, the system shall resume use of that detector in plan selection.

I. Detector group failure - The system shall provide a user adjustable method of determining if enough system detectors are operating to provide meaningful data for selection of a traffic plan. If sufficient data does not exist to select either cycle

length, offset, or split, the master shall revert to a time-of-week/time-of-day plan.

11.3.11 Detector Monitoring:

A. Intersection (Local) Detector Monitoring - A minimum of eight (8) intersection actuation (local) detectors per intersection shall be monitored for constant calls and absence of calls. Threshold values shall be user-definable. The occurrence of local detector failure and subsequent recovery shall be stored for reporting to the microcomputer.

B. System Detector Monitoring - Each system detector shall be monitored for constant calls, absence of calls, and erratic output. All such anomalies shall be reported by the on-street master to the microcomputer. Threshold values for constant calls, absence of calls and volume and occupancy scaling factors shall be user-definable for each system detector. Threshold values for absence of calls shall be capable of being eliminated based on a user-definable threshold.

Alternate: A functionally equivalent system utilizing detector diagnostics as defined in NEMA TS-2 subsection 3.9.3.1.4 shall be an acceptable alternative.

11.3.12 Manual Operation: Means shall be provided in the microcomputers for the operator to manually implement any of the timing plans, flash operation, or free operation for any or all controllers. Such manual operation shall override both traffic-responsive and time-of-week/time-of-day operation.

11.3.13 Preemption: The system shall recognize and log locally initiated preemptions. When any preemption is active, the on-street master shall monitor, but not supervise, the intersection.

11.3.14 Pedestrian Activity Recognition: The background cycle may be exceeded at intersections with walk and pedestrian clearance times in order to provide for safe occasional pedestrian crossings on minor phases Under this mode of operation, the signal will get out of step with the system after the pedestrian has been served. The system shall be designed and set up to recognize the actuation of the pedestrian push-buttons for at least two (2) phases per intersection. The system shall simply resynchronize the signal after this out-of-step condition occurs as a result of the

pedestrian activity. Skipping of a phase to achieve resynchronization shall not be acceptable. No "out-of-synchronization" reports, error messages or other exception messages shall occur under these conditions. These requirements may be implemented through the design of the on-street masters, the controllers, the control equipment cabinets or the applications software or any combination of these.

11.3.15 Scheduler Capacity: The system shall provide a time-of-year scheduler. The scheduler shall provide at least ten (10) independent day schedules for each intersection. Each day schedule for each intersection shall provide a minimum of twenty (20) event (state-change) times with each event time capable of being programmed for all possible function changes that are supported by the controller/time-based coordinator; however, the system shall not be required to provide more than a total of 150 event times per week per intersection. The event times for each day schedule at an intersection shall be independent of the event times for the other day schedules. An alternate scheduling scheme utilizing an equivalent minimum number of events shall be acceptable.

11.3.16 Special Event Day Schedules: It shall be possible to program the system at least seven days in advance to implement any of up to at least three (3) special day schedules to accommodate special circumstances. The special day schedules shall override the normal daily plans.

11.3.17 Leap-Year Adjustment: It shall be possible to program the scheduler to automatically adjust for both the beginning and the end of leap-year up to one year in advance. Alternatively, this adjustment shall not require programming, but shall be inherent in the system design.

11.3.18 Special Function Control: The system shall provide the control of at least three (3) user-definable special functions at each intersection under the control of the scheduler.

11.3.19 Backup Coordination: The intersection controllers shall provide time-of-week/time-of-day time-based coordination when the on-street master is off-line and when there are telemetry failures.

11.3.20 Clock Updates and Accuracy:

A. A clock update shall periodically be automatically down-loaded to the controllers from the central microcomputer and the on-street masters. A means for manual update shall be provided to update all system clocks from the microcomputer.

B. While on battery back-up, the time clock within the on-street master shall maintain an accuracy of 25 parts per million or better. With primary power applied, the accuracy shall be that of the line frequency.

11.3.21 Automatic Daylight Savings Time Adjustment: The master and all system clocks shall perform automatic daylight savings time adjustment.

11.3.22 Number of System Detectors: Each on-street master shall accommodate at least sixteen (16) system detectors.

11.3.23 On-Street Master Data Storage Requirements: The on-street master shall have sufficient capacity to store and format monitored function data for either immediate or future output to one of the microcomputers for a minimum of either 24 hours or 200 events.

11.3.24 Field Communications Checking: The on-street master communications equipment shall perform parity and error checking diagnostics to assure communication of valid system data.

11.4 REPORTING FEATURES AND FUNCTIONS.

11.4.1 General Printed Reports: It shall be possible to easily obtain a printed copy of any report that can be displayed on the microcomputer's screen. It will be acceptable for the scope of any report to be limited to logical functions (as defined by the manufacturer) for those intersections and groups that are associated with a specifically requested on-street master. It shall not be necessary to execute a PRINT SCREEN operation for each report, except that status reports may require the use of the PRINT SCREEN function. The system shall produce the following standard reports.

A. A log of system status changes and failures - This log shall be on demand, however, at least failures shall be printed as they occur if the system is enabled to do so. Events and changes shall also be stored on the hard disk so that the event report can be printed as needed. Reports indicating operating failures at intersections or at on-street masters shall be initiated by each on-street master either at the time of the failure occurrence or within a user programmable time after the occurrence of such a failure. Each log entry shall include the group identification, the time and date of occurrence, the device identification (if a device related event), the intersection identification, if applicable, and the event description.

B. Event report - The event report shall list the events and failures in a concise report. It shall be possible to print the event report from the system files of the hard disk. It shall also be possible to print the events within operator-specified date ranges and segregated by type.

C. Status reports - In response to operator commands, the system shall print status reports on the screen and on paper, as selected by the operator, showing the current status of all aspects of the system. Printing on the screen and on paper is not required to occur simultaneously. At least the following status information shall be included in the status reports.

- On-street master identification.
- Program in effect and its characteristics.
- Status of special functions.
- Telemetry channels on-line and failed.
- Status of each intersection (on-line, off-line, flash, failed, and preempted).
- Status of each detector (operational, failed).
- Operation mode (traffic-responsive, time-of-week/time-of-day or equivalent)

It shall be possible for the operator to suppress the printing of any or all of the status reports.

11.4.2 System Detector Reports: The system shall provide traffic data reports, from data collected from the system detectors at each intersection, and system detector failure reports as described below.

A. The microcomputer shall receive system detector volume and occupancy data from each on-street master and shall record, tabulate, format and output reports of such data as defined below. Such data shall be uploaded from the on-street master on demand and automatically according to a user-defined schedule.

B. Raw system detector data reports shall be recorded at the microcomputer according to a user-defined schedule and displayed or printed on demand as selected by the user.

C. System Detector Failure Reporting - System detectors determined to be failed shall be automatically deleted from volume and occupancy calculations and the event of failure occurrence shall be stored for future reporting.

D. System Detector Count Files - The system shall provide the following functions for collecting and processing system detector count data.

On request from the operator, the system shall log in disk files raw traffic volume data from the system detectors. In building the system detector count file(s), the system shall allow the operator to select the complement of system detectors to be logged. This selection shall also be possible via the scheduler. In accomplishing the logging, the system shall poll the on-street masters at least once per day, but not more than four (4) times a day. The method of polling and storing the count data shall insure that no data is duplicated in the file and that no data is lost. It is permissible that all detectors to be logged simultaneously may be restricted by the system's design to those that are related to the same on-street master. The logging of the system detector count data shall be selectable from menu selections in the closed-loop software. It shall be possible to copy the file(s) containing the system detector counts to diskette using the closed-loop software or the operating system's COPY

program and to actually process the counts on another compatible microcomputer. All count data shall be in 15-minute increments, with each increment beginning on a quarter-hour. Counts from 15 minutes to 168 hours (one full week) shall be accommodated. If errors are detected by the system in the operation of any of the system detectors being logged, the associated data in the logging file shall be replaced with an error code. The error code shall be "ERR".

11.4.3 Spreadsheet Compatible Software: Software shall be provided that will enable the operator to process the system detector count files into spreadsheet form compatible with Microsoft ACCESS or EXCEL format.

11.4.4 Logging: The system shall log on hard disk files all system and intersection status changes and all failures and warnings. It shall also be possible to recall log information from the disk and print all of it or selected subsets (as defined by the manufacturer) of it. It shall also be possible to copy the log file to diskette for permanent storage. The operating system's COPY program may be used for this copying.

11.4.5 Report Routing: All exception reports (failure and warning messages) initiated by the system shall be accomplished by the system on the microcomputer. If the system is equipped with two (2) microcomputers, logging shall be on the primary microcomputer unless the user specifies that the associated report may be accomplished on the secondary microcomputer. When an on-street master is calling the primary microcomputer and said microcomputer is unavailable for any reason, the on-street master shall buffer the information to be transmitted and shall redial the associated microcomputer until connection is established. It shall be acceptable for the user to define those critical types of events that are to be automatically reported.

11.5 USABILITY FEATURES.

The system shall provide the following usability features.

11.5.1 General Principles on Database Entry/Edit: The following principles shall apply to the data entry/editing process provided by the system.

A. Field widths or data formats shall be structured such that the data entry location for each field is clearly definedshown on the screens or protected fields shall be used.

B. All data items entered via the microcomputers shall be tested for data type (numeric or text) and allowed range. All string data items shall be tested to insure that they do not exceed the allowed length. The program shall not terminate because any data item is incorrectly entered. When errors or potential errors are detected, the program shall either display a specific diagnostic message on the screen or shall give an audible alarm and shall place the cursor in the proper field. In either case, the system shall allow the operator to re-enter the item. Prior to or simultaneously with re-entry, the diagnostic message, if any, shall be erased.

C. All numeric data items shall be tested to insure that they are within the ranges allowed by the system and the associated control equipment. Furthermore, all such data items shall be tested for reasonableness (as defined by the manufacturer) considering their application. A specific warning message shall be printed or an audible alarm shall be sounded whenever a data item falls outside the reasonable bench marks and the operator shall be allowed to change the data item if desired.

D. Whenever a logical grouping of data (such as a full screen or the complete database file) has been entered or edited satisfactorily, that data shall be written to the proper file. This may take place upon return to the main menu or, alternatively, it may take place as the entry or editing of each distinct file is ended.

E. The same screen formats shall be used for initial entry and for editing.

F. The screen organization and data entry/edit method shall enable the operator to use all functions without the need to use reference manuals or cards.

G. Simple English Required - All codes shall be simple and all text shall be in simple English and common traffic engineering terminology. It shall not be necessary to perform any decoding to read the information. All necessary codes shall be specifically and discretely provided on the same display as they are needed.

11.5.2 Copy Facility: It shall be possible to copy from within the system all logical

segments of the database to other like segments of the database. Furthermore, it shall be possible to copy all of the database from one (1) microcomputer to the other and vice versa and to copy logical portions of the database (as defined by the manufacturer) from one microcomputer to the other and vice versa. Use of the operating system's COPY utility to accomplish this shall be acceptable, as shall the physical transfer of diskettes from one microcomputer to the other.

11.5.3 Up-load/Down-load of Database:

A. The software shall provide a means to up-load (copy) the database and logical segments thereof from any on-street master and any controller or interface unit via its on-street master to the microcomputer while all equipment is performing its traffic control functions. It shall be possible to down-load (copy) the database for a controller or interface unit or an on-street master and logical segments thereof from the microcomputer to the associated on-street master and to the controller or interface unit via its on-street master.

B. The up-load/down-load feature shall use block transfer techniques with verification. Non-verified data shall cause termination of the up-load or down-load operation with no transfer of the corrupted block taking place. An error message shall be displayed when improper termination of the up-load or down-load operation occurs.

C. It shall be possible to compare the database of any on-street master, any controller or any interface unit to the corresponding database on file in the microcomputer following an up-load. The compare function shall be simply initiated by the operator and shall identify any differences between the up-loaded data and the file data. See paragraph 1060-7G.

NOTE:
It is the policy of the City of Charlotte, that no one may download any of the following parameters from a remote location unless directed by the Engineer. The adherence to this policy shall be the responsibility of the individual, agency, contractor, or other entity which establishes remote communications with any signal system component.

Minimum greens Added initial settings

WALKs	Gap reduction settings
Pedestrian clearances	Overlap definitions
First (yellow) clearances	Lagging overlap settings
Second (red) clearances	Allowable sequences
Unit extensions (passage times)	Preemption sequences or timings

11.5.4 Data Entry Aggregation: The system shall allow data to be entered in logical traffic engineering groupings; that is, all data for an intersection shall be entered together and in logical groupings, all system data shall be entered together and in logical groupings, etc. Any codes needed for data entry or editing shall be displayed on the same screen or display of the microcomputer, the on-street master or the controller, as appropriate, together with the data to be entered or edited. Screens or displays of data on the microcomputer, the on-street masters and the controllers shall utilize essentially the same formats for like data. Logical groupings shall be as defined by the manufacturer.

11.5.5 Data Entry/Edit By Table Fill-In: Data entry screens and editing screens shall be the same for functionally identical data groups. Entry and editing shall be by means of filling in formatted tables. It shall not be necessary to enter data in sequence. Use of the cursor control keys shall allow the cursor to be moved right, left, up and down among the fields of data.

11.5.6 Error/Reasonableness Checking: The system shall perform error checking of the data. No data shall be down-loaded if any data is found to be incompatible with the on-street master or the controller.

11.5.7 Database Comparison: The system shall, upon operator request, compare the database in the microcomputer, and logical segments of it, with that up-loaded from the on-street masters, the interface units and the controllers. The system shall highlight any deviations between the two databases in an effective and easily understood and usable manner.

11.5.8 Menu Driven: The system's interface with the user shall be menu driven.

11.5.9 Use of Mnemonics: The system shall minimize the use of mnemonics to interface with the user on the screen, on the controllers, on the on-street masters, in printed reports and in the system's documentation or worksheets. Only mnemonics consisting of accepted traffic engineering abbreviations and other straightforward abbreviations shall be acceptable.

11.5.10 User Access: The system shall provide at least two (2) levels of access security. One (1) level shall permit the operator to view and change all information in the system. The other level shall permit the operator to view at least the reports and the monitoring information, but shall not permit any changes. This level shall not permit the operator to view the access security codes. Intermediate levels of access may be provided. The system shall require a password before allowing a user to change data stored in a local controller, an on-street master controller or a microcomputer from the microcomputer.

11.5.11 Labeling: All reports and screens associated with specific intersections or groups shall be labeled with the intersection's or group's number or name.

11.5.12 Database Backup and Restoration: The system shall provide the following database backup and restoration features:

1. The system shall include simple means of copying the database files from the hard disk to diskette(s). All files required to restore the system to operation without the need to manually reenter data shall be included on the backup diskette(s).

2. Microcomputer files containing records of events and detector data shall be saved on the microcomputer's hard disk when received from the on-street masters. The system shall enable the simple transfer of such files to storage diskettes. The system shall be capable of analyzing such stored files on diskette by the same programs and producing the same reports as are possible when the files are on the hard disk. Recopy of the diskette files to the hard disk to accomplish this shall be permitted.

3. The system shall provide simple, straightforward means for restoring system operation from the backup database files.

11.5.13 Data Entry/Edit Through On-Street Equipment: In addition to the data entry and editing at the microcomputers, it shall be possible to enter and edit all data via keyboards and displays on both the on-street masters and the controllers.

11.5.14 Intersection Display: Upon operator request, the microcomputer shall display the dynamic operation of any selected intersection in schematic form. The system or stand-alone software furnished as part of the system but operating off-line shall permit the operator to draw the intersection in schematic form or it shall provide preprogrammed graphics that can easily be adapted to the intersections by the operator. If preprogrammed graphics are provided, they shall include at least cross-type intersections and T-type intersections. The display shall accommodate all standard NEMA phasings as well as those that can be produced by the following phase sequences shown: Dual Quad sequence, Quad Sequential sequence, Sequential Sequence and Lead Lag sequences. As a minimum, the display shall show the following:

A. The layout of the intersection with intersection label.
B. All vehicle indications for each active phase and up to four (4) overlaps with red, yellow and green indicators.
C. All pedestrian signal indications for at least four (4) active phases. WALK, flashing DONT WALK and steady DONT WALK shall be shown.
D. Vehicle and pedestrian detector actuations for each active phase.
E. Cycle countdown.
F. Timing plan in effect.
G. Status of special functions.
H. Operational status of the intersection (on-line, standby, off-line, flash, preempted).
I. The actuation status of at least eight (8) intersection detector inputs.

11.5.15 Group Map Display: The system shall provide an active group map display that conforms to the following requirements:

A. The system shall display the on-line status (on-line and off-line) of any selected group or larger subset of intersections in schematic map form on the microcom-

puter. The system shall also display the operational status (operational or failed) of said group and each of its associated system detectors. The information shown in both displays shall be dynamically updated in real-time.

B. The system shall display on the group map the current group operating parameters.

C. The system shall allow the operator to draw the group maps, including grid patterns, 5-legged intersections and angled approaches. This may be done off-line with stand-alone software.

11.6 ON-STREET MASTERS.

Each on-street master shall supervise a group or groups of signalized intersections, providing plan (or cycle, split, offset) and scheduler information to the intersection controllers and interfacing them to the microcomputers. The on-street masters shall also collect monitoring and detector information from the associated intersections, temporarily store it and report it to the microcomputers. Each on-street master required by the plans or the bid list shall satisfy the following requirements.

11.6.1 The on-street master shall be microprocessor-based.

11.6.2 The on-street master shall conform to the requirements of Section 2 and Article 13.2 of NEMA Standards Publication TS-1 or Article 3.2.3 of NEMA Standards Publication TS2-1992.

11.6.3 The on-street master shall be a self-contained unit designed for shelf mounting.

11.6.4 Connection of the on-street master to the microcomputers shall be via the standard dial-up commercial telephone network.

11.6.5 Unless otherwise specified, the on-street master shall include a Hayes or approved equivalent auto-dial/auto-answer modem, either internally or externally, to accomplish the interface to the microcomputers. The modem shall provide for a minimum baud rate of 28,800 and be downward compatible to the master and microcomputer communication baud rate(s).

11.6.6 Connection of the on-street master to the intersection controllers and interface units shall operate over no more than two (2) wire-pairs when a twisted pair wire interconnect cable system is used as the link to local controllers. In twisted pair wire installations, the wire-pairs shall be connected to the intersections in each group. Each on-street master shall include all necessary telemetry with the unit.). Any special cables or connectors between the master or local control unit and a transceiver device in an optical, radio, microwave, or other link, which are not standard to the computer industry and commercially available, shall be included with the controller unit (if bid as a closed loop controller) or the master unit unless otherwise specified in the bid document.

11.6.7 The on-street master shall provide scheduled traffic plan selection; secondary coordinated phase synchronization (unless provided within the intersection controller); diagnostics of itself, the telemetry, the controllers, the interface units, and the system detectors; logging; reporting; and data entry in conformance with Section 11.3.

11.6.8 The on-street master shall have a keyboard(s) located on the front panel permitting entry of all data. A functionally equivalent data entry means may be approved by the City.

11.6.9 The on-street master shall store and retain all information and parameters, except current time, in electrically alterable nonvolatile memory described in Section 11.7.2.

11.6.10 The on-street master shall have a display or displays for the display of data during the data entry process and for display of parameters and operational status. The displays shall be easily readable under all ambient lighting conditions. As a minimum, such displays shall include:

- Parameter values;
- Current operating status;
- Plan command status;
- Cycle synchronization; and
- Operational status of all controllers and detectors (e.g. stand-by, on-line, failed).

11.6.11 In addition to keyboard entry of the data, the on-street master shall allow up-loading and down-loading of the entire database and logical segments of the database from the microcomputers for all local intersections. The on-street master shall store and retain all information and parameters, except current time, in electrically alterable nonvolatile memory. The controller nonvolatile memory shall have a data retention design life of at least ten (10) years and shall provide for a minimum of 10,000 write cycles per memory segment.

11.6.12 The on-street master shall permit the use of a user-specified access code which shall be required in order to change any portion of the database. A master code or other means shall be provided to override the security provided by the user-specified access code.

11.6.13 The on-street master shall continuously perform tests on the system detector data, telemetry communications, and controllers and interface units. Detected faults shall be logged by the on-street master and shall be transmitted to the microcomputer.

11.6.14 Physical and Electrical Requirements: Each on-street master shall conform to the following physical and electrical requirements.

A) All on-street masters shall be of completely solid-state construction. All active devices for logic, timing, and control functions shall be solid-state and shall be sufficiently derated to insure no material shortening of life under conditions of maximum power dissipation at maximum ambient temperature.

B) All timing shall be digital; that is accomplished in discrete intervals. All timing, except splits and offsets, shall be adjustable in seconds, not in percent of the cycle. Splits and offsets shall be adjustable in either seconds or percent of cycle.

C) The on-street master shall be designed so that it shall not be possible to inadvertently connect a harness or a printed circuit board incorrectly.

D) All components shall be arranged so that they are easily accessible for servicing. When modular in construction, guides and positive connection devices

shall be provided to insure proper pin alignment and connection.

E) The on-street master shall have internal diagnostics to aid in identifying master failures. A PROM change to effect the diagnostics will be permissible.

F) One (1) set (not one (1) set per master) of all PROMs, modules, extender boards, harnesses and cables necessary for the proper servicing and diagnosis of the on-street master shall be furnished.

G) The components on all printed circuit boards shall be arranged for ease of access. The components shall be identified by markings on the components and on the boards.

H) Each printed circuit board shall be constructed per the requirements of NEMA TS-2 subsection 3.2.3.

I) All components shall be rated sufficiently beyond their actual minimum requirement in the on-street master so that no material shortening of life will occur under conditions of maximum power dissipation at maximum ambient temperature.

J) All inductors and transformers shall have insulated windings. The insulation shall be impregnated to exclude moisture.

K) All resistors and capacitors shall be insulated and shall be marked with their ratings. Ratings shall be indicated either directly with numerals or by the RETMA color codes. All electrolytic capacitors shall be marked to indicate their polarity.

L) The front panel of the on-street master shall contain all of the following.

- All necessary connectors (except that the communications connector may be on the side);
- The data entry controls;
- All indicators and displays; and
- All necessary fuse holders and fuses or circuit breakers.

Each of these devices shall be neatly and permanently labeled.

M) The AC power supply circuit and DC supply circuits shall each be protected with a fuse or circuit breaker of suitable rating. The ratings of these devices shall be labeled on the on-street master adjacent to them.

N) The on-street master shall be housed in a single, dust- and corrosion-resistant metal enclosure or a properly shielded polymer enclosure. Any unused openings in the enclosure shall be neatly covered with blank panels designed to complement the master's appearance.

O) The connectors shall be firmly mounted on the chassis or on a circuit board with a backing plate.

P) The on-street master shall have a watchdog timer circuit or equivalent functional means to detect unexpected processor halts and to monitor the integrity of the microprocessor's operation.

Q) All like plug-in assemblies shall be directly interchangeable. All modules shall be neatly and systematically arranged and easily accessible. Each module shall have a part number permanently inscribed on it.

R) If the on-street master has a mother-board, it shall have slide-ways and a positive locking device for each module to insure proper pin alignment and pin contact area. Each module shall be provided with a pull-handle or similar device for ease of removal.

S) The power supply shall provide sufficient filtering and capacity to prevent transient voltage spikes from improperly triggering internal on-street master components into operation.

T) During power outages, the real-time clock and memory shall continue to operate on an internal battery or capacitor backup power source. If the backup power source is rechargeable, it shall supply the power for a single outage of 48 hours minimum. Automatic recharging of the rechargeable power source shall occur within 24 hours after resumption of power. If the backup power source is

non-rechargeable, it shall supply the power for a minimum outage of 30 days and shall have a minimum shelf life of five (5) years. The time shall be crystal controlled with an accuracy of ± 0.005 percent throughout the full temperature range.

11.7 PHYSICAL REQUIREMENTS.

11.7.1 Master Display Size: The minimum display size shall be 4 lines by 40 characters per line. LCD displays shall be back-lit.

(A) Readability: The display shall be easily readable under all conditions of ambient lighting including bright sunlight shining directly on the display face. The display shall have back-lighting that will render it readable in darkness.

(B) Life: The display shall have a minimum design life of 20,000 hours at rated voltage.

11.7.2 Master Backup Memory: Backup memory shall be implemented using EEPROM technology or an equally stable commercially available equivalent approved by the Engineer. The controller nonvolatile memory shall have a data retention design life of at least ten (10) years and shall provide for a minimum of 10,000 write cycles per memory segment.

11.7.3 Moisture Resistant Coating: All circuit boards shall have a moisture resistant coating.

SECTION 12
METAL POLES AND ARMS

12.1 GENERAL REQUIREMENTS

This section of the *Specifications* describes metal poles and mast arms for traffic signal support (see Article 16.10 for wood poles). All such poles and mast arms shall conform to the requirements of Section 1 of these *Specifications,* the typical drawings, the plans and the following requirements. The Specifications cover monotube strain and mast arm poles and monotube cantilevered mast arms. The general design of the poles and arms shall conform to the requirements of the plans and the typical drawings with no guys, struts, rods, stay braces, clamps or U-bolts, except where noted otherwise.

12.1.1 AASHTO Specifications

The design of the completed assembly of poles, mast arms and hardware shall equal or exceed the current AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals* (AASHTO Specifications), and addenda thereto, assuming ice and average winds for a 25-Year Mean Recurrence Interval with a 1.3 gust factor when loaded in accordance with the typical drawings, the plans and these *Specifications*.

12.1.2 Design Drawings and Calculations

Design drawings, showing design details, and copies of the design strength and deflection calculations for each completed pole/arm structure shall be submitted with the submittal data (see Article 1.3) for review and acceptance prior to fabrication. The ASTM specification numbers for the materials to be used shall be included as part of the design strength calculations. The types and sizes of all welds shall be shown on the design drawings. All design drawings and calculations shall be signed, dated and sealed by the responsible Registered Professional Engineer. Such Registered Professional Engineer shall be registered in the State of North Carolina. Said Registered Professional Engineer shall immediately bring to the attention of the Engineer any structural deficiency which becomes apparent in any structure or member of any structure as a result of the design requirements imposed by these *Specifications*, the plans or the typical drawings. Said Registered Professional Engineer shall be wholly responsible for the design of all poles and arms and review and acceptance of these designs by the Department shall not relieve said Registered Professional Engineer of this responsibility.

12.1.3 Dimension Limits

Each complete pole/arm assembly shall be within the dimension limits shown on the drawings.

12.1.4 Structural Cross-Sections

All poles and mast arms shall have a round or near-round cross-sectional design consisting of no less than six (6) sides. The sides may be straight, convex, or concave.

12.1.5 Cable Outlets

The design shall permit all cables to be installed inside poles and mast arms. All holes in the poles and arms to accommodate cables shall have full-circumference grommets. These grommets shall be installed prior to wiring of the pole or arm. The grommets shall not be cut or split.

12.1.6 Galvanizing

All steel poles and mast arms, including all parts used in the assembly (except the standard length galvanizing on the anchor bolts), shall be completely hot-dip galvanized after fabrication. All threaded material shall be brushed and retapped as necessary after galvanizing. Hot-dip galvanizing on the structure shall be in accordance with ASTM Standard A-123. Galvanizing on the hardware shall be in accordance with ASTM Standard A-153.

12.1.7 Repair of Galvanized Steel

The repair of damaged galvanizing shall be in accordance with the *Standard Specification*s.

12.1.8 Masses and Areas of Signal Heads, Signs, and Cables to be Supported

In the design of the pole/arm structures, the following masses and areas shall be assumed.

12.1.8.1 The combined minimum weight of a messenger cable bundle (including messenger cable, signal cable and detector lead-in cables) shall be assumed to be 1.94 kg/m. The combined minimum diameter of this cable bundle shall be assumed to be 33 mm.

12.1.8.2 Signal head on mast arm, including backplate and Astro-Brac (or equivalent):

- 1-way, 3-section, 200 mm

  Mass: 19.5 kg

  Projected area: 0.63 m^2

- 1-way, 4-section (vertical-type), 200 mm

Mass: 24.3 kg

Projected area: 0.74 m^2

- 1-way, 5-section, 200 mm

  Mass: 34.0 kg

  Projected area: 1.02 m^2

- 1-way, 3-section, 300 mm

  Mass: 27.4 kg

  Projected area: 0.88 m^2

- 1-way, 4-section (T-type), 300 mm

  Mass: 40.8 kg

  Projected area: 1.53 m^2

- 1-way, 4-section (vertical-type), 300 mm

  Mass: 33.6 kg

  Projected area: 1.09 m^2

- 1-way, 5-section, 300 mm

  Mass: 46.7 kg

  Projected area: 1.53 m^2

12.1.8.3 Signal heads attached to span wire, including backplate, hanger and balance adjuster:

- 1-way, 3-section, 200 mm

  Mass: 18.6 kg

  Projected area: 0.63 m^2

- 1-way, 4-section (vertical-type), 200 mm

  Mass: 22.2 kg

  Projected area: 0.74 m^2

- 1-way, 5-section, 200 mm

  Mass: 28.1 kg

Projected area: 1.02 m^2

- 1-way, 3-section, 300 mm

  Mass: 25.4 kg

  Projected area: 0.88 m^2

- 1-way, 4-section (T-type), 300 mm

  Mass: 33.1 kg

  Projected area: 1.53 m^2

- 1-way, 4-section (vertical-type), 300 mm

  Mass: 31.3 kg

  Projected area: 1.09 m^2

- 1-way, 5-section, 300 mm

  Mass: 40.4 kg

  Projected area: 1.53 m^2

12.1.8.4 All signal heads attached to pole or pedestal shaft, worst case, common mounting:

Mass: 61.2 kg

Projected area: 0.88 m^2

12.1.8.5 Signs with span wire hanger or Astro-Brac (or equivalent):

- 600 mm x 750 mm sign

  Mass: 5.0 kg

  Projected area: 0.47 m^2

- 750 mm x 750 mm sign

  Mass: 5.7 kg

  Projected area: 0.58 m^2

- 750 mm x 900 mm sign

  Mass: 6.4 kg

  Projected area: 0.70 m^2

12.1.9 Ice Loading

The ice loading shall be computed on the basis of 15 mm of ice at 961 kg/m^3 on the surfaces of cables, signals, poles and mast arms and on one (1) face only of sign panels.

12.2 POLES

All poles shall conform to the following requirements.

12.2.1 General

Each pole shall be fabricated from a single piece of steel or aluminum and shall have no transverse butt welds. Poles shall conform to the following requirements.

12.2.1.1 Pole Types

Each kind of pole (mast arm or strain) shall be classified by type. Type 0 applies only to strain poles and indicates that the pole does not support a mast arm. Types 1, 2 and 3 apply to both mast arm poles and strain poles with mast arm attachments. The types indicate the lengths of mast arms which the pole shall be designed to support as follows:
Type 1 - Up to 9.1 m arm;

Type 2 - 9.1$^+$ to 13.7 m arm; and

Type 3 - 13.7$^+$ to 15.2 m arm.

The poles shall be permanently stamped above the hand holes with their type numbers and the manufacturer's name or logo.

12.2.1.2 Worst-Case Loads

The poles and hardware shall be designed to support the worst-case loads as shown in the typical drawings or the plans.

12.2.l.3 Pole Deflection

The allowable pole deflection, when loaded with the worst-case signal and sign dead loads specified above, in the typical drawings and in the plans, shall not exceed that allowed by the AASHTO Specifications. For span wire poles (with primarily transverse loads) the maximum deflection at the top of the pole under the worst dead load conditions shall not exceed 2.5 per cent of the pole height. For mast arm poles (with primarily moment loads) the maximum angular rotation of the top of the pole under the worst dead load conditions shall not exceed 1° 40'. For combination poles with both

span wire and mast arm attachments, the worst of the two criteria shall govern in sizing the pole.

12.2.1.4 Base Plate

Each pole shall have a base plate. The anchor bolt holes in the pole base plate shall be 7 mm larger than the anchor bolt diameters. Anchor bolt holes in the base plates shall be elongated to provide adequate adjustment of the pole's orientation.

12.2.1.5 Hand Hole

Each pole shall have a 100 mm x 205 mm hand hole with a reinforcing frame. The hand hole in each pole shall be 150 mm above the base plate. Types 1, 2 and 3 poles shall also have 100 mm x 205 mm hand holes opposite the mast arm attachment.

12.2.1.6 Hand Hole Covers

The hand hole shall be furnished with a cover and screws. In addition, 20 percent spare hand hole covers shall be furnished with each order. For small orders, at least one (1) spare cover shall be furnished with each order. The hand hole cover furnished with the pole shall be attached to the pole by a sturdy chain or cable. The chain or cable shall be long enough to permit the cover to hang clear of the compartment opening when the cover is removed. The chain or cable shall be strong enough to prevent vandals from being able to disconnect the cover from the pole. It shall be attached to the pole and the cover in a manner that will be vandal-proof. The chain or cable shall not interfere with service to the cables in the pole base.

12.2.1.7 Pole Cap

Each pole shall be furnished with a removable pole cap for the top. Suitable stainless steel attachment screws shall also be furnished. The cap shall be cast aluminum conforming to Aluminum Association Alloy 356.0F. It shall be furnished with and attached to the pole by a sturdy chain or cable approved by the Department. The chain or cable shall be long enough to permit the cap to hang clear of the pole-top opening when the cap is removed.

12.2.1.8 Anchor Bolts

Anchor bolts shall be furnished with each pole. Two (2) anchor nuts and two (2) washers shall be furnished for each bolt. Anchor bolts shall be fabricated from steel with a minimum yield strength of 370 MPa and a minimum ultimate tensile strength of 483 MPa. Anchor bolts shall have diameters, lengths, and positions as required by the typical drawings and shall develop strengths comparable to their respective poles. Each anchor bolt shall have a 90-degree bend or a plate at the unthreaded end. If a plate is

used, it shall be adequate to prevent pull-out of the bolts. The number of anchor bolts furnished shall conform to the requirements of the typical drawings.

12.2.1.9 Pedestrian Signals and Pushbuttons

All poles shall be designed to accommodate 2 pedestrian signals with pushbuttons. Pedestrian signals shall be banded to the pole as shown on Standard Drawing SIG-4 and a 25 mm hole with rubber grommet shall be provided to feed the cable from the signal into the pole. Pushbuttons may be banded to the pole or attached directly using screws. A 25 mm hole with rubber grommet shall be provided to feed the cable from the pushbutton into the pole.

12.2.1.10 Grounding Lugs

Each pole shall be equipped with a 12 mm minimum thread diameter, coarse thread stud and nut for grounding which will accommodate an A.W.G. #4 ground wire. The lug shall be electrically bonded to the pole and shall be conveniently located inside the pole at the hand hole.

12.2.1.11 J-Hook

Each pole shall have a J-hook inside the pole opposite the mast arm attachment. The J-hook shall be mounted 150 mm above the hand hole.

12.2.1.12 Additional Fittings

Each pole shall be drilled and furnished with such additional fittings as may be shown on the plans or called for in the Project Special Provisions.

12.2.1.13 Taper

The taper for all shafts shall begin at base. The diameter shall decrease uniformly at the rate of not more than 11.7 millimeters per meter of length.

12.2.1.14 Bolt Covers

Cast aluminum bolt covers shall, when called for on the bid list or plans, be furnished and attached to the base by means of one (1) hex head cap screw each.

12.2.1.15 Materials and Construction

Poles shall be either aluminum or steel as indicated on the plans or the bid list.

A. Aluminum Poles

1. The poles shall be fabricated from Aluminum Association Alloy 6061-T6, 6063-T6, or approved equivalent.
2. The shaft shall be tapered by spinning and cold-working a seamless extruded tube of the aluminum alloy.

3. The shaft shall have no longitudinal or circumferential welds except at the lower end joining the shaft to the base.

4. The shaft, unless otherwise specified, shall be satin brush finished and individually "tire wrapped".

5. The base of the shaft shall be of Aluminum Association Alloy 356.0-T6, of adequate strength, shape and size, and capable of withstanding the design load of the shaft.

6. All aluminum surfaces in contact with concrete or dissimilar metal shall be coated with bituminous paint.

B. Steel Poles

1. Shafts shall be of the tapered tubular type and fabricated of steel conforming to ASTM A-595 Grade A or an approved equivalent and shall be galvanized in accordance with ASTM A-123.

2. Shafts shall be continuously welded for the entire length by the submerged arc process. The exposed welds shall be ground or rolled smooth and flush with the base metal. The shaft shall have no circumferential welds except at the lower end joining the shaft to the base. All welding shall conform to the provisions of the *Standard Specifications* for welding structural steel. No field welding on any part of the pole will be permitted.

3. Anchor bases for steel poles shall be fabricated from plate steel meeting the requirements of ASTM A 36M or cast steel meeting the requirements of ASTM A 27M Grade 485-250 or an approved equivalent.

12.2.2 Mast Arm Poles

Mast arm poles shall conform to the requirements of Article 12.1 and paragraph 12.2.1 of these *Specifications* and to the following requirements.

12.2.2.1 Mast Arm Attachment

Each mast arm pole shall be furnished with a pole plate and associated gussets and fittings for the attachment of the appropriate type of mast arm.

12.2.2.2 Pole Base

Each mast arm pole shall have either a shoe base or transformer base as indicated on the plans or in the bid list. Transformer bases shall include all necessary fittings and attachments. The transformer base, if provided, shall have a large door opening with a removable door provided in the side of the base. The transformer base shall be

furnished with four (4) galvanized bolts, each with a hex nut and two (2) washers for attaching the pole to the transformer base.

12.2.3 Strain Poles

Strain poles shall conform to the requirements of Article 12.1 and paragraph 12.2.1 of these *Specifications* and to the following requirements.

12.2.3.1 Mast Arm Attachment

Type 0 strain poles shall not accommodate mast arms. Each Type 1, 2, and 3 strain pole shall be furnished with a pole plate and associated gussets and fittings for the attachment of the appropriate type of mast arm. The orientation angle, in degrees, shall be stamped on the pole above the hand hole and adjacent to the type stamp. As part of the mast arm attachment, a grommeted cable passage hole shall be provided in the pole to allow passage of the signal cables from the pole to the arm.

12.2.3.2 Messenger Cable Attachment Provisions

Each strain pole shall include a span wire clamp and associated hardware, for each span attachment on a pole, for the attachment of the support cable of the span wire suspension. The diameter of the clamp shall be appropriate to its location on the pole.

12.2.3.3 Cable Outlets

A 50 mm hole equipped with a weatherhead shall be provided on the span wire load side of the pole to accommodate passage of the signal cables from inside the pole to the suspension. Holes should be drilled and weatherheads installed after the pole is erected. Holes shall be a minimum of 150 mm above the highest attachment and a minimum of 150 mm below the top of the pole. The number of holes with weatherheads in each pole shall be specified by the engineer.

12.3 MAST ARMS

Mast arms shall conform to the requirements of Article 12.1 and to the following requirements.

12.3.1 Arm Fabrication

All mast arms up to and including 15.2 m arms shall be fabricated from one (1) piece monotube steel or aluminum. Mast arms shall not have any transverse butt welds.

12.3.2 Mast Arm Deflection

The maximum total deflection at the tip of the mast arm due to the combined deflection

of the pole and the arm itself shall not exceed 2.5 per cent of its length under the worst-case dead load conditions.

12.3.3 Mast Arm Attachment

The mast arm shall be fastened to the pole per the manufacturers instructions. The arm plate and all necessary attachment hardware, including bolts and brackets, which are not included as part of the pole, as described in Article 12.2, shall be furnished as part of the arm. Fifty (50) percent spare bolts shall be furnished with each order.

12.3.4 Holes for Signal Cable

Grommeted holes shall be provided on the underside of the mast arm to accommodate the cables for the signals. Holes shall be located within 300 mm of the signal heads.

12.3.5 Weatherproof Connections

Mast arms shall be furnished with weatherproof connections for attaching to the shaft of the pole.

12.3.6 Hardware

All hardware shall be galvanized steel, stainless steel, or corrosive-resistant aluminum.

12.3.7 End Cap

The end of the mast arm shall be equipped with a weatherproof cast aluminum cap which can be removed for wiring access. The cap shall be held in place by stainless steel set screws. The cap shall be of Aluminum Association Alloy 356.0F. It shall be furnished with and attached to the arm by a sturdy chain or cable. The chain or cable shall be long enough to permit the cap to hang clear of the arm end opening when the cap is removed.

12.3.8 Materials and Construction

Mast arms shall be the same material as the support poles.

12.3.8.1 Aluminum Arms

A. Aluminum mast arms shall conform to the Aluminum Association Alloy 6061-T6, 6063-T6 or approved equivalent.

B. The requirements for welding aluminum arms shall be the same as those for welding aluminum poles.

C. Aluminum mast arms shall be satin brush finished and individually wrapped unless otherwise specified on the bid list or plans.

12.3.8.2 Steel Arms

A. Steel mast arms shall be standard weight black steel pipe conforming to ASTM A 53-90a, Type E or Type S, Grade B or an approved equivalent.

B. All steel mast arms shall be hot-dipped galvanized inside and outside after all fabricating, cutting, punching, and welding is completed.

C. All welding of steel which is permitted shall conform to the provisions of the *Standard Specifications* for welding structural steel.

SECTION 13
PEDESTALS

13.1 GENERAL

This section of the *Specifications* sets forth minimum design requirements which apply to pedestals supporting vehicular and pedestrian signals and traffic signal controller cabinets. The requirements of Section 1 of these *Specifications* apply to the pedestals.

13.2 DESIGN REQUIREMENTS

The pedestals shall be new, shall be aluminum, and shall conform to the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* (AASHTO Specifications), the following design requirements, and the requirements of the Typical Drawings.

13.2.1 Pedestal Heights

The lengths and types of pedestals shall conform to the requirements of the bid list or the plans. Unless otherwise specified on the plans or in the bid list, pedestals shall have the following standard heights for the conditions indicated.

13.2.1.1 Pedestals supporting only traffic signal controller cabinets: 760 mm above the foundation.

13.2.1.2 Pedestals supporting vehicular signal heads or pedestrian signal heads mounted on top of the pedestal: 2.5 m above the foundation.

13.2.1.3 Pedestals supporting pedestrian signal heads mounted on the side of the pedestal: 3.4 m above the foundation.

13.2.1.4 Pedestals supporting vehicular signal heads or vehicular and pedestrian signal heads combined mounted on the side of the pedestal: 4.6 m above the foundation.

13.2.2 Caps and bases shall be included as part of the pedestal assembly.

13.2.3 The shaft shall not be welded.

13.2.4 The top of the shaft shall accommodate a 115 mm slip-fitter for mounting the signals or cabinets.

13.2.5 The complete pedestal assembly, including signals and a 1.4 m^2 wind-loaded area mounted to provide maximum moment, shall be capable of withstanding the force of an

130 km/h wind without excessive deflection, vibration, flutter or structural failure.

13.2.6 Pedestal Base

A. The pedestal base shall be made of Aluminum Association Alloy 356.0 or approved equivalent.

B. The pedestal base shall be designed to break upon impact in accordance with the AASHTO Specifications.

C. The pedestal shall have either a shoe-type or a transformer-type base as required by the plans or the bid list.

- The shoe-type base shall consist of an aluminum flange plate with four (4) anchor bolt holes and a hole to match the pedestal shaft. The pedestal shall have a hand-hole located approximately 205 mm above the base. The hand-hole shall be 100 mm x 205 mm and shall have a reinforcing frame.
- The transformer-type base shall be approximately 380 mm high x 330 mm wide x 330 mm deep. It shall have a hand-hole, with a removable cover, that is approximately 205 mm x 205 mm or larger.

D. The base shall be continuously welded to the shaft or shall be threaded to receive the shaft.

E. The base shall have a 12 mm minimum thread diameter, coarse thread stud and nut installed for use in grounding. The stud shall be located inside the base at the hand-hole and be oriented so that it is easily accessible.

F. The bolt circle and layout of the base shall conform to the requirements of the typical drawings.

G. Detailed drawings of templates for setting the anchor bolts shall be furnished with each pedestal. Alternatively, in lieu of multiple drawings, a single reproducible drawing, satisfactory to the City, may be furnished with each order.

13.2.7 Pedestal Shaft

A. Pedestal shafts shall be aluminum fabricated from Aluminum Association 6061-T6 or 6063-T6 alloy or approved equivalent. The minimum thickness of the shaft shall be 3.2 mm.

B. The shaft shall be circular in cross-section and shall be either a tapered tube or a straight pipe with a 100 mm inside diameter. The diameter of tapered aluminum

pedestals shall begin at the base and decrease at a taper rate of not more than 11.7 mm per meter of length.

C. The pedestal shaft shall be formed by spinning and cold-working a seamless extruded tube of aluminum alloy.

D. Unless otherwise specified, the shaft shall have a satin brush finish and be individually wrapped for protection during shipment.

13.2.8 Pedestal Caps

Pedestal caps shall be cast aluminum conforming to Aluminum Association Alloy 356.0F and shall use stainless steel set screws as fasteners.

13.2.9 Hardware

13.2.9.1 Anchoring Hardware

Each pedestal shall be furnished with anchoring hardware meeting the following requirements.

A. The number of bolts for each pedestal shall be in accordance with the manufacturer's specifications.

B. The anchor bolts shall be completely hot-dip galvanized in accordance with ASTM A-153. The nuts and washers shall also be completely galvanized.

C. Each anchor bolt shall have a 50 mm right-angle bend at the end which is to be embedded in the concrete.

13.2.9.2 Installation Hardware

All necessary installation hardware shall be furnished with each pedestal.

SECTION 14
TRAFFIC SIGNALS AND ACCESSORIES

This section sets forth the Specifications for vehicular and pedestrian signals, for school speed limit beacon assemblies and for changeable message/blank out signs. The requirements of Section 1 apply.

14.1 VEHICULAR SIGNALS

This article of the *Specifications* covers both aluminum signals and plastic vehicular signals. All vehicular signals shall conform to the following requirements. The number and size of the sections in each signal head shall conform to the requirements of the plans or the bid list. All vehicular signals and assemblies shall conform to the "Vehicle Traffic Control Signal Heads" section of the Equipment and Materials Standards of the Institute of Transportation Engineers (ITE Standards), unless otherwise noted. Vehicular signal heads shall be made entirely of plastic sections unless otherwise specified by the plans or special provisions, except that the top section of 5 section “doghouse” type signals and 4 section in-line signals shall always be aluminum.

14.1.1 General

The following general requirements shall apply to all vehicular signal heads.

14.1.1.1 Each vehicular signal head shall consist of one (1) or more signal faces arranged in a suitable mounting framework to satisfy the requirements of the plans or the bid list.

14.1.1.2 Signal heads shall be arranged for vertical mounting unless otherwise specified on the plans or the bid list.

14.1.1.3 Traffic signals shall be tested by either method described below using three-section heads. The test results shall be furnished to the City as part of the submittal data (see Article 1.3). The tests shall be conducted on signal heads of each size (200 mm, 300 mm) to be furnished. The City will accept the results of tests conducted on batches of signal heads other than those furnished, provided that a certified statement is provided stating that the furnished signal heads are identical to those tested.

A. Test Method 1

A three-section head with a nominal 200 mm backplate, when completely assembled and supported solely from the top or bottom section, shall withstand the laboratory equivalent of a sustained wind load of 1200 Pa applied perpendicularly to the signal face and backplate. "Withstand" shall mean that the specified load shall not cause any damage to the signal face or backplate nor any permanent deformation sufficient to adversely affect performance of the signal face or backplate. The 200 mm width of the

backplate shall apply to the top, bottom and sides.

B. Test Method 2

Each metal three-section head, completely assembled except for visor, shall meet the following strength test when supported at the bottom in a vertical position by a standard 100 mm x 40 mm post top slip-fitter, nipple, and lock nut on a short rigid length of standard 100 mm pedestal and base and subjected to a horizontal force as indicated below, one-third of which is applied at the center of each section of the head, whether the lenses face in the direction of the applied force or in the opposite direction.

Nominal Lens Diameter	Net Deflection Shall Not Exceed 25 mm At	Breaking Strength Shall Be Not Less Than
200 mm	467 N total force	667 N total force
300 mm	266 N total force	400 N total force

Net deflection is the deflection at a point 6 mm below the top of the signal head minus the deflection at a point of the slip-fitter 145 mm below the bottom of the signal head. Total force is the sum of the three (3) equal forces applied at the center of each of the three (3) sections of the signal.

14.1.2 Construction

14.1.2.1 The housing of each section shall be one-piece complete with integrally cast top, bottom, and sides. Two (2) integrally cast hinge lugs shall be provided on the left of each section housing. Integrally cast latch screw lugs shall be provided on the right side of each housing section. One (1) lug shall be provided for 200 mm sections and two (2) lugs shall be provided for 300 mm sections. A plastic signal section shall not weigh more than a similar size aluminum section.

14.1.2.2 The door of each signal section shall be hinged to the housing so as to permit access to the section for relamping. The door shall be secured with a simple metal mechanical screw device or other latching features that will hold the door tightly closed when the section is subjected to a wind load corresponding to 1200 Pa. It shall be possible to open and close the door without the use of any tools.

14.1.2.3 Each 200 mm signal section shall be 255 ± 25 mm high. Each 300 mm signal section shall be 355 ± 25 mm high.

14.1.2.4 A gasket groove on the inside of the door shall accommodate a gasket. The gasket shall

be provided. It shall be a weatherproof and mildew-proof air-core resilient neoprene gasket, which, when the door is closed, shall seal against a raised bead on the housing, making a positive weatherproof and dust-proof seal.

14.1.2.5 The outer face of the door shall have four (4) tapped holes equally spaced about the circumference of the lens opening with four (4) 18-8 stainless steel slotted-head screws to accommodate the signal visor in the correct position for both horizontal and vertical mounting of the signal face.

14.1.3 Optical System for Incandescent Lamps

The optical system of each section shall conform to the following requirements.

14.1.3.1 Lens

Vehicular signal lenses shall conform to the following requirements.

A. The lens shall be standard red, yellow, or green, or specified stenciled red, yellow or green arrow traffic signal lens.

B. The lenses shall conform to the American National Standards Association Specification D 10.1-1966, UDC-656.057 where applicable. Unless otherwise specified on the plans or the bid list, all lenses shall be glass. If polycarbonate lenses are specified, the material shall conform to the ASTM Specifications D788-84 Grade 8 or D-3935-87 grade.

C. Directional arrow lenses shall have the same brilliance, no matter which direction they are pointed.

D. The lens shall fit into a specially designed one-piece slotted air-core neoprene lens gasket designed to fit the housing door in such a manner so as to exclude moisture, dust, and road film. The lens and gasket shall be provided with an open slot extending completely around the circumference of the gasket to accommodate the lens clips in such a manner that the lens may be easily rotated and aligned without removing the lens, gasket, or clips.

14.1.3.2 Reflector

The reflector shall be a one-piece parabolic specular aluminum with anodic coating.

14.1.3.3 Lamp Holder

The lamp holder shall be designed to accommodate all standard 40 to 150-watt traffic signal lamps and to automatically position the filament of the lamp at the exact focal point of the reflector so that an accurate focus will always be obtained. The lamp

holder shall be designed so that it can be easily rotated and positively positioned without the use of any tools and provide proper lamp filament orientation without affecting the lamp focus.

14.1.3.4 Reflector Ring

A. The reflector and lamp holder shall be held in place in a die cast aluminum reflector ring by means of a cadmium, zinc or tin plated spring-wire bail.

B. The reflector ring and complete reflector and socket assembly shall be pivoted between two (2) stainless steel pins in such a manner that it can be swung open for ease in servicing the signal without the use of any tools. The reflector, reflector ring, lamp holder, and spring-wire bail shall be designed so that they may be moved or replaced individually or as a complete unit without the use of any tools.

14.1.3.5 Optical System for Light Emitting Diode (LED) Traffic Signals

This specification provides performance requirements for LED indications intended for retrofit of existing signal lamps including 300mm and 200mm ball indications and 300mm arrow indications.

14.1.3.5.1 Physical

Installation into existing traffic signal housings built to the ITE Vehicle Traffic Control Signal Heads (VTCSH) standard shall be without modification to the housing and shall not require special tools. Installation of a retrofit LED signal shall only require the removal of the existing optical unit components, i.e., lens, lamp module, and gasket; shall be weather tight and fit securely in the housing; and shall connect directly to existing electrical wiring.

14.1.3.5.2 LED Signal Module Lens

Shall be capable of replacing the existing colored signal lens. The outside lens surface shall be smooth to reduce the collection of debris and facilitate cleaning. The lens may be uniformly tinted to enhance ON/OFF contrasts in a manner not to affect luminous intensity or chromaticity. The lens shall be easily replaceable in the field without the need of any special tools or adhesives in the event of vandalism or vehicle impact. The lens shall be keyed to the housing to assure proper orientation. The lens material shall be Ultraviolet (UV) stabilized polycarbonate to withstand direct sunlight exposure for a minimum of 5

years without exhibiting evidence of deterioration.

14.1.3.5.3 Environmental Requirements

LED signals shall be rated for continuos use in the ambient temperature range of -40°C (-40°F) to +74°C (+165°F) and be protected against dust and moisture intrusion per the requirements of NEMA Standard 250-1991 for Type 4 enclosures when properly mounted and oriented in the signal housing.

14.1.3.5.4 Construction

The LED signal shall be a self-contained device not requiring on-site assembly and be capable of withstanding mechanical shock and vibration per MIL-STD-883, Test Method 2002 when properly mounted in the signal housing.

14.1.3.5.5 Materials

The LEDs shall be indium based AllnGap technology for red and amber, and GaN for green. The lens and signal module shall conform to ASTM specifications where applicable. Enclosure and lens material shall have a minimum UL94-V2 flame retardant rating.

14.1.3.5.6 Module Identification

Module identification shall be provided on each LED signal for traceability purposes. Identification shall include: manufacturer's name, trade, and serial number specified, operating voltage, power consumption, and volt-amperes. A permanent indexing indicator, i.e., ≠,UP, or TOP shall be provided for proper orientation in signal housing.

14.1.3.5.7 Luminous Intensity & Spatial Light Output Distribution

Luminous intensity and spatial output distribution shall meet the minimum initial intensity requirements as defined in Section 11.04 of the VTCSH standard after operating for 30 minutes at 117 V rms and +25°C (+77°F).

14.1.3.5.8 Chromaticity (Color)

Coordinates of LED signal modules shall conform to the chromaticity

requirements of Section 8.04 and Figure 1 of the VTCSH standard.

14.1.3.5.9 Electrical

Wiring shall be captive, color-coded, 0.91m (36 in.) long, 16 AWG minimum in accordance with Section 13.02 of the VTCSH standard.

14.1.3.5.10 Voltage Range

Operation from 80V to 135V at 60 Hz ac shall prevent perceptible flicker. All test measurements shall be taken at 117V rms.

14.1.3.5.11 Transient Voltage Protection and Fusing

Transient voltage protection and fusing shall be provided to withstand high-repetition noise transients and low-repetition high energy transients per Section 2.1.6 of NEMA Standard TS-2, 1992.

14.1.3.5.12 LED Drive Circuitry

The individual LED light sources shall be wired so that a catastrophic failure of one LED light source will not result in the loss of illumination in more than 20 percent of the LED light source. The LED on-board circuitry must meet Federal Communications Commission (FCC) Title 47, CFR Subparts B. Section 15.107, 109, regulations concerning the emission of electronic noise.

14.1.3.5.13 Electronic Noise

The LED on-board circuitry must meet Federal Communications Commission (FCC) Title 91, Part 15A regulations concerning the emission of electronic noise.

14.1.3.5.14 Certificate of Compliance

The LED indication shall conform to the ITE standard in effect at time of order plus amendments or exceptions listed on purchase order, and shall be shipped with each lot of LED signals.

14.1.3.5.15 Warranty

LED signals shall be warrantied for 60 months of field operation against failure due to workmanship or material defects and against loss of luminous intensity such that the signal no longer conforms to the VTCSH standards.

14.1.4 Visors

Each signal section shall be furnished with a visor on the door.

14.1.4.1 Visors shall be 200 mm tunnel type, unless otherwise noted on the plans or the bid list, and shall encompass 80 percent of the lens circumference.

14.1.4.2 Visors shall have twist-on attaching ears to facilitate installation. The visors shall be constructed in such a manner that they can be installed or removed from the signal head without removing the attaching screws.

14.1.4.3 Visors for aluminum signal sections shall be made from 1.25 mm (minimum) thick aluminum alloy sheet. Visors for plastic signal sections shall be either formed from

sheet plastic or assembled from one or more injection, rotational or blow-molded plastic sections.

14.1.5 Gaskets

Each signal section shall have the following gaskets.

A. Door Gasket - A neoprene hollow core door gasket shall provide positive seal between the door and signal housing.

B. Lens Gasket - A special one-piece slotted air-core neoprene lens gasket shall provide the seal between the lens and signal door and between the lens and reflector ring.

C. Lamp Holder Gasket - A socket gasket to provide a cushion and a positive seal between the reflector and lamp holder.

14.1.6 Mounting Assemblies

Each traffic signal head shall accommodate the type of mounting required by the plans or the bid list. Mounting assemblies shall conform to the following requirements.

14.1.6.1 All traffic signal mounting brackets and fittings shall be watertight when assembled.

14.1.6.2 Each mounting fitting in contact with a signal section shall match the positive locking device on the section and shall have 40 mm (inside diameter) threaded in accordance with NEC specifications for rigid metal conduit.

14.1.6.3 Brackets shall be 40 mm (inside diameter) standard pipe or rigid conduit, or cast, molded or extruded metal. All brackets shall be of sufficient strength to withstand both the vertical loading of the signal faces and horizontal wind loading corresponding to 1200 Pa. "Withstand" shall mean no damage or permanent deformation sufficient to adversely affect the normal performance of the signal.

14.1.6.4 All brackets shall have raceways free of sharp edges and protrusions that might damage conductor insulation and shall be of sufficient size to accommodate at least ten (10) A.W.G. #14 conductors with 1.143 mm thick insulation.

14.1.6.4.1 A metal re-inforcement plate shall be installed between the signal head and the mounting bracket on all plastic three, four, and five section signal heads as shown in the detail drawings.

14.1.6.5 Mast arm slip-fitters and span wire suspension fittings shall include means for adjusting the signal head to the proper vertical alignment, including a universal mounting bracket.

14.1.6.5.1 Mast arm swinging mount brackets shall be installed as shown in the detail drawings.

14.1.6.6 Signal heads to be span wire mounted shall, in addition to the upper suspension fitting, accept mounting attachments for securing the signal to a lower span wire. Such mounting attachments shall be furnished when specified on the bid list or plans.

14.1.6.7 All mounting hardware shall be malleable iron unless otherwise allowed by the Engineer. Serrated rings shall be aluminum.

14.1.7 Miscellaneous Fittings and Parts

All exposed screws and fasteners shall be 18-8 stainless steel. All interior screws, fasteners, and metal parts shall be stainless steel or corrosion resistant materials. If ferrous materials are used, they shall be protected against corrosion by cadmium, zinc or tin plating. Zinc coatings of ferrous components shall be applied in accordance with ASTM B 633-85 or ASTM B 695-91. Tin platings of ferrous components shall be applied in accordance with ASTM B 545-83. The thickness of the applied coatings shall be a minimum of 5 μm. All cadmium plating shall meet the minimum requirements of Federal Specification QQ-P-416E, Type II, Class A.

14.1.8 Exterior Finish

All signal heads shall be finished as follows.

14.1.8.1 Plastic Heads - All exterior surfaces of the housing and the mounting assembly, except backplates, louvers and the insides of visors, shall be yellow meeting Federal Standard 595A, Color Chip # 13538 unless otherwise specified. Backplates, louvers and the insides of visors shall be dull black. The colors shall be completely impregnated in the plastic material with the exception of the insides of the visors, which shall be painted dull black.

Aluminum signal heads shall be finished either by spray painting or by a dry powder method.

A. Spray Painting Method - All exterior surfaces of the signal housing, door, visors, louvers and backplates shall be finished with at least two coats of the best quality infrared oven baked paint before assembly, except that all threads are to be free of paint and shall not require cleaning or chasing. The stainless steel latching device shall not be painted.

   1. First Coat: Primer - Shall be Zinc Chromate or Epon, Oxide Baking Primer, and shall meet of exceed the performance of MIL-P-53030.

2. Second Coat: Yellow Enamel - Shall be Traffic Signal Yellow Alkyd Urea Exterior Baking Enamel, except on the inside of the visors. Color shall conform to Federal Standard 595A, Color Chip # 13538.

3. Second Coat on Backplates, Louvers and Inside of Visors - The second coat on the backplates, louvers, and insides of the visors shall be an Alkyd Urea Black Synthetic Baking Enamel, with minimum gloss reflectance, and shall meet the performance requirements of MIL-E-10169 Enamel Heat Resisting, Instrument Black.

A third coat of paint equivalent to the second coat may be applied. The thickness of the second coat or the combined thickness of the second and third coats shall be 0.051 mm minimum.

B. Dry Powder Method - All exterior surfaces of the signal housing, door, visors, louvers and backplates shall be finished with dry powder before assembly, except that all threads are to be free of paint and shall not require cleaning or chasing. The stainless steel latching device shall not be painted. Finish colors shall be the same as specified under the Spray Painting Method. Finishes applied using the dry powder method shall conform to the following requirements.

1. The finish shall be applied by cold electrostatic spray and heat cured.

2. The film thickness shall be 0.06 to 0.09 mm for yellow and 0.04 to 0.05 mm for black.

14.1.9 Wiring

Each socket shall be provided with two (2) color-coded leads with spade-type terminals. The leads shall be A.W.G. #18 600-volt insulated wire with 105-degree Celsius thermoplastic insulation. The insulation shall not be degraded by exposure to hydrocarbon-based compounds. Each complete signal face shall be provided with a terminal block. Terminal blocks shall be placed in the amber section unless otherwise specified. The terminal block shall be a barrier type block with the indicated number of terminals.

Number of Sections In Signal Face	Minimum Number of Terminals Required
3	4
4	5
5	6

Each terminal shall have two (2) terminal screws with a shorting bar between them. Each terminal screw shall accept a 5 mm spade lug. To one side of each terminal block shall be attached white, red, yellow, and green signal section leads, leaving the opposite terminals for field wires.

14.1.10 Hanger Extension Assemblies

Hanger Extension Assemblies shall have a tri-stud design, be constructed of aluminum, and be finished with Federal Yellow enamel paint. The assembly, when mounted to the signal head, shall keep the signal head water tight. Other types of hanger extension assemblies may be used with approval by the Engineer.

14.1.11 Signal Head Backplates

Signal head backplates shall meet the following requirements:

14.1.11.1 Materials

The signal head backplates shall be constructed of sheet aluminum a minimum of 1.2 mm thick, and shall extend at least 125 mm from the outline of the signal head. The backplate shall be secured to the signal head using stainless steel "L" brackets and stainless steel screws. A minimum of two mounting brackets shall be used per signal section. Pop rivets shall be used to secure the mounting brackets to the backplate, and to secure all joints within the backplate.

14.1.11.2 Finish

The backplate assembly shall be painted flat black per Section 14.1.8

14.1.11.3 Fit of Backplate

The backplate assembly shall fit the signal head for which it was provided. A 7 mm maximum gap between the backplate the signal head, as viewed from the front, shall be allowed. The backplate shall not interfere with the function of any hardware used to mount the signal head to the span wire or mast arm. The backplate shall not interfere with the operation of the door hinges or latches of the signal sections, and shall allow the signal section doors to open to a minimum of 90°. The backplate shall fill in gaps between cluster mounted signal sections (for example: T-type heads or 5-section heads).

14.1.12 Strobe Signal Sections

The strobe lights are mounted in the red section. The strobe section emits a periodic pulse of white light during the red interval. Signal head mounted strobe beacons must meet the following requirements.

14.1.12.1 Orientation

The strobe section shall operate in eigher a verical or horizontal orientation. Unless otherwise spedified, the section shall be provided for the vertical orientation.

14.1.12.2 Assembly

The strobe section shall be comprised of a standard signal section with a strobe assembly. The strobe assembly shall be powered by the red indication power. All electronic equipment necessary to flash the strobe shall be mounted in or on the strobe section. The strobe bulb shall be mounted in front of the red lens (which shall be made of glass unless otherwise specified) and behind a clear non-yellowing lens. The strobe assembly shall be watertight and dust-tight. Terminal blocks with high voltage connections shall be screw type with high barriers and encapsulated back. Terminal blocks for high voltage connections shall be thermoplastic material or other material which, unlike themoset or phenolic materials, does not carbonize under arcing conditions. The terminal block shall be sized to provide sufficient distance (at least 1.25cm) between high voltage connections and ground such that there is not a path to ground either through mounting screws or by terminal proximity to mounting surfaces. The distances between high voltage and ground shall be sufficient to prevent a ground path even after normal build up of dust, humidity, and debris over a 5 year period. Silicon RTV used near terminals in the assembly shall be electrical grade type which is noncorrosive to metals. The location and mounting of strobe components shall not interfere with changing the traffic signal lamp.

14.1.12.3 Display

The strobe shall be positioned horizontally when the signal is mounted in its intended orientation. The strobe light shall be clearly visible from a distance of 300 meters in sunlight. The strobe light shall flash at a rate of approximately once per second.

14.1.12.4 Bulb

The bulb shall be a xenon tube no more that 10mm in diameter. The bulb shall be

supported in its position. Bulb duty life shall be 5000 hours minimum.

14.1.12.5 Field-Accessible Connections

All field-accessible connections shall be made with pressure connections which are adequately supported and insulated.

14.1.12.6 Size

Unless otherwise specified, strobe signal heads shall be nominal 300mm diameter lens type vehicle heads.

14.1.12.7 Environmental Requirements

The strobe assembly shall operate over the ambient temperature range -37 to 73°C in an environment up to 95% humidity. Each component shall be rated sufficiently for the assembly to operate within this ambient temperature and humidity range.

14.2 PEDESTRIAN SIGNALS

Pedestrian signals shall conform to the following requirements. This article of the *Specifications* covers aluminum and plastic versions of the single section pedestrian signals. The number and size of the sections in each signal head and its material type shall conform to the requirements of the plans or the bid list. All pedestrian signals and assemblies shall conform to "Pedestrian Traffic Control Signal Indications" section of the latest Equipment and Materials Standards of the Institute of Transportation Engineers (ITE Standards), unless otherwise noted.

14.2.1 General

Each pedestrian signal head shall consist of one (1) signal face arranged in a suitable mounting framework to satisfy the requirements of the plans or the bid list.

14.2.2 Construction

14.2.2.1 Each signal section shall have an opening in the top and bottom for mounting purposes. Each opening shall be round to accommodate 40 mm (inside diameter) threaded in accordance with NEC specifications for rigid metal conduit. Each unused opening shall be closed with a gasketed plug to make a weather- and dust-tight closure.

14.2.2.2 The housing of each section shall be one-piece complete with integrally cast top, bottom, and sides. Two (2) integrally cast hinge lugs shall be provided on the left of each section housing. Two integrally cast latch screw lugs shall be provided on the right

side of each housing section. The top and bottom of the housing shall each have a positive locking mechanism cast into the housing at the mounting opening to provide positioning of the entire signal face without rotation or misalignment. Adjustment in five (5) degree increments shall be provided.

14.2.2.3 Materials - Pedestrian signal section materials shall conform to the requirements for vehicular signals.

14.2.2.4 The door of each signal section shall be hinged to the housing so as to permit access to the section for relamping. The door shall be secured with a simple metal mechanical screw device or other latching features that will hold the door tightly closed when the section is subjected to a wind load corresponding to 1200 Pa. It shall be possible to open and close the door without the use of any tools.

14.2.2.5 A gasket groove on the inside of the door shall accommodate a gasket. The gasket shall be provided. It shall be a weatherproof and mildew-proof air-core resilient neoprene gasket, which, when the door is closed, shall seal against a raised bead on the housing, making a positive weatherproof and dust-proof seal.

14.2.2.6 The outer face of the door shall have four tapped holes about the perimeter of the lens opening with four 18-8 stainless steel slotted-head screws to accommodate the signal visor.

14.2.3 Optical System for Incandescent and Light Emitting Diode (LED) Pedestrian Signals

The optical system of each section shall conform to the following requirements.

14.2.3.1 Lens

Pedestrian signal lenses shall conform to the following requirements.

A. All pedestrian signals shall provide the international walking person and raised hand symbols. The message shall be transmitted by the illumination of the signal lens.

B. The lens shall be glass and shall be designed for continuous exposure to weather.

C. The lens shall conform to the ANSI Specification D 10.1-1966, UDC-656.057 where applicable.

D. All lenses shall be uniformly colored throughout the body of the material, true to size and form, and free from any streaks, wrinkles, chips, or bubbles that in any way impair their light transmission or distribution.

E. The lens shall fit into a specially designed one-piece slotted air-core neoprene lens gasket designed to fit the housing door in such a manner so as to exclude moisture, dust, and road film.

14.2.3.2 Illuminating Element Receptacle(s)

The illuminating element receptacle shall be of heat resisting material and shall be provided with a grip to prevent loosening of the illuminating element(s) due to vibration, temperature changes or other causes. If the illuminating element(s) are incandescent lamp(s), the receptacle material shall allow lamps with brass or aluminum bases to be used without the receptacle and the lamp base binding to hinder insertion and removal of the lamp.

14.2.3.3 Incandescent Illuminating Elements

Each pedestrian signal section shall be furnished with illuminating element(s) conforming to the requirements of Article 16.6 of these *Specifications* as applicable to the section size.

14.2.3.4 LED Illuminating Elements

LED illuminating elements shall easily retrofit into a standard housing using existing screw-based sockets and meet ITE portland orange color requirements. In addition the LED illuminating elements shall conform to the ITE standard in effect at time of order.

14.2.3.5 Double Parabolic Reflector

Single section pedestrian signals shall have a single-piece double parabolic reflector. The reflector shall be formed from either sheet aluminum or vacuum-formed from polycarbonate plastic sheet. The polycarbonate reflector shall be reflectorized by vacuum-deposition of an aluminum coating. The two sections of the reflector shall be divided so that light spillage from one section to the other is prevented when assembled with the message lens.

14.2.4 Visors

Each signal section shall be furnished with a gridded visor. Gridded visors shall consist of at least fifteen (15) vertical members and at least 26 horizontal members plus at least two (2) integral locking strips to prevent vandalism. The depth of the visor shall be approximately 40 mm and the horizontal members shall be spaced 13 mm apart. The vertical and horizontal members shall be either aluminum or polycarbonate material.

14.2.5 Gaskets

Each signal section shall have at least the following gaskets.

A. Door Gasket - A neoprene hollow core door gasket shall provide positive seal between the door and signal housing.

B. Lens Gasket - A special one-piece slotted air-core neoprene lens gasket shall provide the seal between the lens and signal door and between the lens and reflector ring.

14.2.6 Mounting Assemblies

Mounting assemblies for pedestrian signal heads shall conform to the following requirements.

14.2.6.1 All pedestrian signal mounting brackets and fittings shall be watertight when assembled.

14.2.6.2 Each mounting fitting in contact with a signal section shall match the positive locking device on the section and shall have 40 mm (inside diameter) threaded in accordance with NEC specifications for rigid metal conduit.

14.2.6.3 Brackets shall be 40 mm (inside diameter) standard pipe or rigid conduit, or cast, molded or extruded metal. All brackets shall be of sufficient strength to withstand both the vertical loading of the signal faces and horizontal wind loading corresponding to 1200 Pa. "Withstand" shall mean no damage or permanent deformation sufficient to adversely affect the normal performance of the signal.

14.2.6.4 All brackets shall have raceways free of sharp edges and protrusions that might damage conductor insulation and shall be of sufficient size to accommodate at least ten (10) A.W.G. #14 conductors with 1.143 mm thick insulation.

14.2.6.5 It shall be possible to mount both pedestrian and vehicular signals in the same mounting assemblies.

14.2.7 Miscellaneous Fittings and Parts

All exposed screws and fasteners shall be 18-8 stainless steel. All interior screws, fasteners, and metal parts shall be stainless steel or corrosion resistant materials. If ferrous materials are used, they shall be protected against corrosion by cadmium, zinc or tin plating. Zinc coatings of ferrous components shall be applied in accordance with ASTM B 633-85 or ASTM B 695-91. Tin platings of ferrous components shall be applied in accordance with ASTM B 545-83. The thickness of the applied coatings shall be a minimum of 5 μm. All cadmium plating shall meet the minimum requirements of Federal Specification QQ-P-416E, Type II, Class A.

14.2.8 Wiring

Each illuminating element socket shall be provided with two color-coded leads with spade-type terminals. The leads shall be A.W.G. #18 600-volt insulated wire with 105-

degree Celsius thermoplastic insulation. The insulation shall not be degraded by exposure to hydrocarbon-based compounds. Each complete signal face shall be provided with a terminal block. Terminal blocks shall be placed in the DONT WALK section unless otherwise specified. Each terminal shall have two (2) terminal screws with a shorting bar between them. To one side of each terminal block shall be attached white, red, and green signal section leads, leaving the opposite terminals for field wires.

14.2.10 Exterior Finish

The exterior finish of pedestrian signals shall conform to the same requirements as the exterior finish for vehicular signals.

14.3 SCHOOL SPEED LIMIT BEACON ASSEMBLIES

Each school speed limit beacon assembly shall consist of a speed limit sign and a one-or two-section, 200 mm signal face on a slipfitter mounting. LED illumination may be substituted for incandescent illumination when required by the bid list or the plans. These signal sections shall conform to the requirements of Article 14.1. The assembly shall conform to the requirements of the plans. Both sections of the signal face shall be equipped with yellow lenses. Each assembly shall be furnished with all of the mounting hardware shown in the plans. If required by the bid list or the plans, each school speed limit beacon assembly shall also include a Type F2 beacon controller assembly conforming to the requirements of Section 10 of these *Specifications*.

14.4 CHANGEABLE MESSAGE SIGN

This article sets forth functional and design requirements for changeable message/blank out signs.

14.4.1 General Requirements

14.4.1.1 The sign shall have the legend and be of the size required by the plans or the bid list. The color of the legend message shall conform with the requirements of the Manual on Uniform Traffic Control Devices. The message shall be white on a black background unless otherwise specified.

14.4.1.2 A barrier type terminal block shall be provided inside the sign for the connection of the associated signal cable. Each terminal shall have two (2) terminal screws with a shorting bar between them. The terminal block shall have a common terminal and a terminal for each color to be illuminated.

14.4.1.3 The sign shall have wire entrances and mounting fittings that are compatible with standard traffic signal mounting hardware.

14.4.2 Electro-mechanical Changeable Message Signs

Electro-mechanical Changeable Message Signs shall satisfy the requirements of paragraph 14.4.1 and the following requirements.

14.4.2.1 The sign shall display either a single or double message as shown in the plans or directed by the Engineer.

14.4.2.2 The sign, both single and double, shall consist of two hinged outer panels which close over a center panel or open to display a sign face.

14.4.2.3 The display interval shall be capable of being controlled manually, by a sensor device, by a remote signal, or with a conventional clock timer.

14.4.2.4 The sign face shall be composed of reflective sheeting. The message, border, and background color shall conform to the *"Manual of Uniform Traffic Control Devices."*

14.4.2.5 The sign shall be capable of properly functioning in rain, snow, wind, and temperatures from -40° F to 140° F.

14.4.2.6 The sign shall be capable of being mounted to any standard size wood or metal pole.

14.4.2.7 The sign shall be constructed from 6061-T6 aluminum components.

14.4.2.8 The sign's drive mechanism shall consist of a chain drive, cam driven, self-locking device with positive drive on both cycles with spring override.

14.4.2.9 The drive motor shall be a 115V AC, magnetic break, non-reversing, gear reduction type motor. All drive mechanism parts shall be enclosed in a corrosion resistant box.

14.4.3 Fiber Optic Blank-Out Signs

Fiber optic blank-out signs shall satisfy the requirements of paragraph 14.4.1 and the following requirements.

14.4.3.1 The sign shall operate properly within the ambient temperature range of -37 and +45 °C and within a voltage range from 105 volts to 130 volts, 60 Hertz.

14.4.3.2 The light energy shall be transmitted to the sign face from the light source by bundles of glass fibers.

14.4.3.3 Two (2) light sources shall be provided for each color. The sign shall be designed so

that failure of one of these light sources shall not cause the legend associated with the color to extinguish, but to be reduced in intensity.

14.4.3.4 Lamps for the light sources shall have a rated life of 8,000 hours minimum at rated voltage.

14.4.3.5 If the sign utilizes lamps rated for less than 120 volts, a separate transformer shall be provided for each light source for redundancy. The transformers used to reduce the voltage shall contain Class A insulation and weatherproofing. The volt-ampere rating of the transformer shall be at least 10 percent greater than the requirements imposed by the load.

14.4.3.6 Power consumption shall not exceed 100 watts per color.

14.4.3.7 Unless otherwise required by the plans, symbols and text legends shall be solid rather than outlined. The apparent text stroke widths and symbol dimensions shall conform to the requirements of the MUTCD and the plans, taking into account the halation effect of the illumination.

14.4.3.8 The sign shall display a clearly visible message even when illuminated in bright sunlight. The message shall appear with full intensity when viewed from anywhere within a 60-degree cone of vision as measured perpendicular to the sign face.

14.4.3.9 When the sign is off, the message shall not be legible even with bright sunlight shining on the face of the sign.

14.4.3.10 Finish - The blank-out sign shall be finished as follows.

A. The exterior of the sign case shall be finished as required for vehicular traffic signal heads in Article 14.1.8.

B. The interior of the sign case shall be finished with two coats of dull black paint.

C. The visor/sun screen, if any, shall be painted with two coats of dull black.

14.4.3.11 The message shall be mounted in or on a hinged door which forms a weathertight seal (via gasket) with the sign case.

14.4.3.12 The material of the sign case shall be 3.175mm thick aluminum. There shall be a 25.4mm diameter vent plug located in each lower corner of the housing to prevent the collection of water from possible gasket leaks. Each vent plug shall have a screen which allows the passage of water but does not readily allow insects to enter the housing.

14.4.3.13 There shall be a wiring diagram secured to the interior of the sign for easy wire tracing.

14.4.3.14 The fiber optic unit shall be completely self-contained and removable from the door.

14.5 CERTIFICATIONS AND SAMPLES

When requested by the City, the manufacturer shall furnish certification as to the conformance of the signal heads, school speed limit beacon assemblies and blank out signs to these *Specifications* based on tests made at an independent testing laboratory.

14.6 OPTICALLY PROGRAMMABLE SIGNAL HEADS

This article of the *Specifications* covers optically programmable vehicular signal heads. These signal heads shall adhere to the standard specifications in Section 14.1 “Vehicular Signals” unless otherwise noted below. All vehicular signals and assemblies shall conform to the "Vehicle Traffic Control Signal Heads" section of the Equipment and Materials Standards of the Institute of Transportation Engineers (ITE Standards), unless otherwise noted.

14.6.1 Construction

14.6.1.1 The housing of each section of the optically programmable traffic signal shall be one-piece complete with integrally cast top, bottom, and sides. Hinge lugs shall be provided on each section housing. Integrally cast screw lugs shall be provided on the other side of each section housing.

14.6.1.2 The signal section shall be constructed so that it can be tilted in two (2) degree increments for a maximum of ten (10) degrees above the horizontal and ten (10) degrees below the horizontal, while still maintaining a common vertical axis.

14.6.1.3 The signal section shall mount as a single or multiple section to industry standard 40mm fittings as described in Section 14.1.6 and 14.1.10. The signal section shall also be mountable in combination with standard traffic signals.

14.6.1.4 All screws and fasteners shall be stainless steel as described in Section 14.1.7.

14.6.2 Optical System

Programming is accomplished optically with the use of a lamp, a diffuser, an optical limiter, and an objective lens. No hoods or louvers shall be required.

14.6.2.1 The lamp shall be a nominal 150 watt, 115 VAC lamp with integral reflector and an average life of at least 6000 hours as rated by the manufacturer. The lamp shall be rated at a nominal 1600 lumens. The lamp shall be held secure in the signal section.

14.6.2.2 The diffuser shall be either integral or discrete to the optical limiter.

14.6.2.3 The optical limiter shall be manufactured from heat-resistant glass. It shall provide an accessible imaging surface at focus on the optical axis for objects 275-366 meters distant. The optical limiter shall also provide a masking surface for signal programming.

14.6.2.4 The objective lens shall be a high resolution annular incremental lens sealed within weather-resistant acrylic or an Engineer-approved equal. The lens may be rotated to any 90 degree orientation on the optical axis without displacing the primary image. The objective lens shall be red, yellow, green, or specified stenciled red, yellow, or green arrow traffic signal lens.

14.6.2.5 The indication from the lens shall conform to ITE transmittance and chromaticity standards. No indication shall result from external illumination.

14.6.3 Optical Masking Tape

An application-specific opaque tape shall be provided with each signal assembly in order to mask the optical limiter.

SECTION 15
WIRE AND CABLE

This section of the *Specifications* sets forth minimum design requirements which apply to various types of wire and cable used in traffic signal installations. The types of wire and cable covered in this section are:

Signal cable
Interconnect cable
Messenger cable
Loop lead-in cable
Loop wire
Ground wire (grounding electrode conductor)
Preemptor detector cable
Electric service wire
Pedestrian push-button cable
Fiber optic cable
Lashing Wire
Video Cable

15.1 GENERAL REQUIREMENTS

The requirements of Section 1 of these *Specifications* and the following general requirements shall apply to all wire and cable.

15.1.1 Referenced Specifications

References to IMSA Specifications shall mean the *Wire and Cable Specifications* of the International Municipal Signal Association, Incorporated.

15.1.2 Testing, Certification and Sample

15.1.2.1 Testing

All wire and cable furnished under this section of the *Specifications* shall be tested to verify at a minimum the continuity of the conductors and, if electrical wire or cable, the insulation resistance of the wire or cable. Testing shall be conducted prior to shipment.

15.1.2.2 Certification

The wire and cable supplier(s) shall furnish a certified report for each type of wire and cable being furnished which states that the wire or cable fully complies with the requirements of these *Specifications*. It is not necessary that the report be for samples of the specific batches of wire and cable furnished, provided that a statement shall be

attached to the certified report indicating that the batches furnished were manufactured under the same conditions as the batches which were tested.

15.1.2.3 Samples

When requested, samples of the wire or cable which is to be supplied shall be furnished without cost to the City for inspection and testing by the City.

15.1.3 Non-Returnable Reels

All wire and cable shall be supplied on non-returnable reels.

15.2 SIGNAL CABLE

Signal cable shall be used to connect traffic and pedestrian signals and other devices to controller cabinets. Low voltage pedestrians pushbuttons shall not be connected to the controller cabinet using the same cable as the conection for high voltage signals.

15.2.1 The requirements of Article 15.1 apply.

15.2.2 Signal cable shall conform to the current Specification 19-1 or 20-1 of the International Municipal Signal Association Incorporated (IMSA). The jacket of each signal cable shall be labeled with the IMSA specification number.

15.2.3 Signal cable shall be 12 conductor A.W.G. #14 unless specified otherwise.

15.2.4 Pedestrian pushbutton cable shall be 4 conductor A.W.G. #14 unless otherwise specified.

15.2.5 All conductors shall be of solid copper.

15.3 INTERCONNECT CABLE

Interconnect cable is cable used to connect intersections with one another or with a master control system. Interconnect cable shall satisfy the following requirements. Unless otherwise noted in the bid list or on the plans, interconnect cable shall conform to the requirements of Article 15.1 and to the following current specifications of IMSA, as applicable for the specific application shown on the plans or as specified in the bid list.

15.3.1 Paired Interconnect

Paired interconnect cable shall be used for Closed Loop system communications and other communications at nominal voltage levels less than 100 volts. Cable shall be selected from the following schedule.

Non-Figure-8 Cable for Aerial Installation:	Specification IMSA 40-2
Non-Figure-8 Cable for Conduit	

Installation: Specification IMSA 40-2

Figure-8 Cable: Specification IMSA 40-4

Direct-Burial Cable: Specification IMSA 40-6

15.3.2 Marking

The IMSA specification number shall be labeled on the jacket of each interconnect cable at intervals not exceeding 600 mm.

15.3.3 Number of Conductors

The number of conductors shall be as indicated in the bid list or on the plans.

15.3.4 Size of Conductors

All conductors shall be A.W.G. #19 and be of solid copper unless otherwise specified.

15.4 MESSENGER CABLE

Messenger cable is steel cable used to support or guy signal heads, signal cable, interconnect cable and other devices. Messenger cable shall conform to the requirements of Article 15.1 and to the following requirements.

15.4.1 The diameter of messenger cable used to guy poles shall be 9.53 mm. The diameter of messenger cable used to support signal heads, signal cable, interconnect cable and other devices shall be as shown on the chart below.

Span (M)	No. of Signal Heads	Sag	Dead Load Stringing Tension (kN)	Req'd Min. Cable Tensile Capacity (kN)	Req'd Cable Diameter (mm)	Cable	AST M Desig-nation	Zinc Coatin g Class
30	5	0.05	4.00	14.90	6.35	Ex.High Str.	A-475	A
45	8	0.05	6.10	22.50	6.35	Ex.High Str.	A-475	A
60	8	0.05	7.20	26.50	6.35	Ex.High Str.	A-475	A
75	8	0.05	8.50	31.10	9.53	Ex.High Str.	A-475	A
90	8	0.05	9.20	33.80	9.53	Ex.High Str.	A-475	A

15.4.2 Messenger cable shall be fabricated of seven (7) steel wires which are twisted into a single concentric strand to conform to the requirements of ASTM A 475-89 for Extra

High Strength Grade Wire Strand, Class A zinc coating.

15.4.3 Galvanizing shall conform to ASTM A 475-89.

15.5 LOOP LEAD-IN CABLE

Loop lead-in cable is cable used to connect a detector loop at the roadside to a detector unit in a control equipment cabinet. Two (2) types of lead-in cable shall be furnished as required by the bid list. Type 2 shall not be used for direct burial. Loop lead-in cable shall conform to the requirements of Article 15.1 and to the following requirements.

15.5.1 Type 1 Lead-In Cable

This polyethylene insulated, polyethylene jacketed loop detector lead-in cable shall conform to the specifications set forth in IMSA Specification 50-2 except as follows:

A. The conductor size shall be A.W.G. #14.

B. The jacket shall have a minimum average thickness of 1.15 mm with a minimum thickness of 1.02 mm at any point.

C. The polyethylene jacket compound shall have a carbon black content of 2.5 to 5.0 percent based on the ASTM test method D 1603.(Intentionally left blank)

15.5.3 Type 3 Lead In Cable

Type 3 Lead In Cable shall meet the requirements of Section 15.3 of these Specifications.

15.6 LOOP WIRE

Loop wire is wire used for forming a detector loop sensing element in the pavement. It shall conform to the requirements of Article 15.1 and to the following requirements.

15.6.1 General

Loop wire shall be composed of 19-strand conductor insulated by a cross-linked polyethylene compound. The insulated conductor shall be completely encased in a tube of low density polyethylene compound.

15.6.2 Conductor

15.6.2.1 The conductor shall be copper and shall, before insulating, conform to the requirements of ASTM B-3.

15.6.2.2 The conductor shall have nineteen (19) strands.

15.6.2.3 The stranded conductor shall utilize either concentric or bunch stranding and shall conform to the circular mil area and physical requirements specified in ASTM Designation B-8 or ASTM Designation B-174, for bunch stranding.

15.6.2.4 The conductor size shall be A.W.G. #14.

15.6.3 Conductor Insulation

15.6.3.1 The insulating compound shall be cross-linked thermosetting black polyethylene (ASTM D-2655-80).

15.6.3.2 The insulation shall be applied concentrically about the conductor. The thickness of the insulation shall be not less than 0.66 mm at any point with a minimum average thickness of 0.76 mm. The method of measurement and the apparatus used shall be in accordance with Underwriters Laboratories, Incorporated Standard UL62 (ANSI C33.1).

15.6.3.3 The insulation after, application to the conductor, shall comply with the requirements specified for cross-linked thermosetting polyethylene (ASTM D-2655-80).

15.6.3.4 The insulation of the finished conductor shall withstand without break down the application of a 60 Hertz or 3000 Hertz, 7500 volt (RMS) essentially sinusoidal spark test potential in accordance with the method and using equipment specified in Underwriters Laboratory, Incorporated Standard UL83 (ANSI C33.8).

15.6.4 Protective Tube

The insulated conductor shall be factory-installed in a protective encasing tube conforming to the following requirements.

15.6.4.1 The encasing tube shall be a polyethylene compound conforming to ASTM D-1248 for Type I, Class C, Grade E5.

15.6.4.2 The encasing tube shall conform to the following dimensions:

Inside Diameter:	3.8 mm minimum
Wall Thickness:	1.0 ± 0.25 mm
Outside Diameter:	6.1± 0.25 mm

15.6.4.3 The name of the manufacturer, the year of manufacture, and any applicable part number shall be printed on the encasing tube at intervals of 600 mm or less.

15.7 GROUND WIRE (GROUNDING ELECTRODE CONDUCTOR)

Ground wire shall conform to the requirements of Article 15.1 and to the following requirements.

15.7.1 All ground wire shall be copper and shall be A.W.G. #6 or #4, as required.

15.7.2 Ground wire for bonding fixed elements shall be bare, soft-drawn and solid if not in conduit.

15.7.3 Ground wire for bonding fixed elements shall be green insulated and stranded if in conduit.

15.7.4 Ground wire for bonding elements, any of which are movable, shall be braided conductor having a cross-sectional area equivalent to A.W.G. #6.

15.8 PREEMPTOR DETECTOR CABLE

Preemptor detector cable is cable used to connect a preemptor detector or other calling device to a control equipment cabinet backpanel. Preemptor detector cable shall conform to the requirements of Article 15.1 and to the following requirements.

15.8.1 The preemptor detector cable shall be 3 conductor A.W.G. #20, 7/28 stranded tinned copper per ASTM B-286.

15.8.2 The insulation shall be high density polyethylene meeting ASTM D1248 Type III Class A-5 Grade E-8.

15.8.3 Each conductor shall be coded with solid insulation color as follows:

1. Yellow
2. Blue
3. Orange

15.8.4 The insulated conductors shall be cabled together to form a substantially cylindrical core.

15.8.5 An overall aluminum/mylar tape shall be spirally applied with an overlap. Aluminum foil shall be facing out in contact with a A.W.G. #20 7/28 tinned copper drain wire.

15.8.6 The jacket shall have a minimum 1.1 mm average wall thickness of chrome gray 80°C polyvinyl chloride compound.

15.8.7 The average calculated finished O.D. shall be 6.35 mm.

15.9 ELECTRIC SERVICE CABLE

Electrical service cable is cable used to connect a power company secondary service to a control equipment cabinet. Electrical service cable shall be 2-conductor signal cable conforming to the requirements of Article 15.2. Alternatively, two (2) separate conductors with THW insulation shall be used. A third conductor shall be provided for grounding. Unless otherwise noted, A.W.G. #10 conductors shall be required.

15.10 PEDESTRIAN PUSH-BUTTON CABLE

Pedestrian push-button cable is cable used to connect pedestrian push-buttons to the associated control equipment cabinets. It shall conform to the requirements set forth in Article 15.2.

15.11 FIBER OPTIC CABLE

Fiber optic cable is non-electric cable used to transmit information between units of communications equipment via light rays. It shall conform to the requirements of Article 15.1 and to the following requirements.

15.11.1 Single-Mode Fiber Optic Cable

Single-mode fiber optic cable shall be appropriate for use outdoors in conduit without connectors. It shall have the number of fibers required by the plans or the bid list and shall conform to the following requirements.

Cladding diameter	125.0 μm
Core diameter	8 to 10 μm
Core eccentricity	1.0 μm maximum
	0.3 μm typical
Attenuation	0.40 dB/km maximum at 1300 nm
Temperature range	-34.5° to +74° C
Coating diameter	245 to 250 μm
Cable construction	Loose buffer
Outer jacket	Polyethylene
Minimum bending radius	305 mm maximum
Tensile strength	2670 N
Central member	Dielectric

15.11.2 Multi-Mode Fiber Optic Cable

Multi-mode fiber optic (MMFO) cable shall meet the optical requirements of the Fiber Distributed Data Interface (FDDI) standards and shall be appropriate for use outdoors in conduit without connectors. It shall have the number of fibers required by the plans or the bid list and shall conform to the following requirements.

Cladding diameter:	125.0 μm
Core diameter:	62.5 μm
Temperature range:	-34.5° to +74° C
Cable construction:	Loose buffer
Outer jacket:	Polyethylene
Minimum bending radius:	230 mm maximum
Tensile strength:	2670 N
Central member:	Dielectric

15.11.3 Single-Mode/Multi-Mode Combination Fiber Optic Cable

Single-Mode/Multi-Mode Combination Fiber Optic Cable shall consist of a quantity of Single-Mode fibers as well as a quantity of Multi-Mode fibers within the same cable. The specific fiber count shall be determined by the plans or the bid list and shall conform to the requirements set forth in Articles 15.11.1 and 15.11.2.

15.12 **LASHING WIRE**

Lashing Wire shall have a diameter of 1.14 mm and stainless steel Alloy 430.

15.13 **VIDEO CABLE**

All Video Cable shall be pre-approved by the Engineer prior to use.

SECTION 16
MISCELLANEOUS ITEMS

This section of the *Specifications* sets forth the requirements for various items. These items shall conform to the requirements of Section 1 of these *Specifications* and to the following requirements.

16.1 PEDESTRIAN PUSH-BUTTONS

Pedestrian push-buttons conforming to the following requirements shall be furnished as required by the plans or the bid list.

16.1.1 Each pedestrian push-button shall have a die-cast aluminum housing with a diameter of approximately 75 mm. The housing shall be weather tight, but shall have a weep hole in the bottom.

16.1.2 The housing shall be suitable for mounting on both flat and curved surfaces.

16.1.3 The housing shall be Federal yellow unless otherwise specified.

16.1.4 The unit shall have a heavy duty push-button assembly with a button having a diameter of at least 18 mm. A larger button may be specified in the bid list or on the plans.

16.1.5 The unit shall have a sturdy, momentary, normally-open switch. The push-button shall be rated for a minimum of 5 mA at 24 volts DC and 250 mA at 12 volts AC. The contacts shall be entirely insulated from the housing and the push-button.

16.1.6 The housing shall be threaded in accordance with NEC specifications for rigid metal conduit to accept a 15 mm conduit. This hole shall be either in the back or in the top/bottom of the unit as required by the plans or the bid list.

16.1.7 The unit shall be vandal-resistant.

16.2 SPEED ANALYSIS UNIT

This article of the *Specifications* sets forth the requirements for a speed analysis unit that will detect the occurrence of vehicle speeds that exceed a set threshold and will activate a warning device. Vehicle detection is by means of wire loops embedded in the pavement. For purposes of this article, the loops and associated lead-in cables are not considered part of the speed analysis unit. The speed analysis unit shall conform to the following requirements.

16.2.1 The unit shall compute the speeds of vehicles crossing a two-loop trap when the upstream edges of the loops are 3 m ± 50 mm apart.

16.2.2 The unit shall provide an output suitable for driving load switches when a vehicle speed in excess of the set threshold occurs. The output shall be provided by Form C relay contacts rated for 2 amperes minimum.

16.2.3 The unit shall permit selection of the threshold speed in two (2) switch-selectable ranges:

Range 1: 10 to 120 km/h; and

Range 2: 20 to 240 km/h.

These ranges shall have the following maximum adjustment increments:

Range 1: 10 km/h; and

Range 2: 20 km/h.

16.2.4 The unit shall detect speeds with an accuracy of ±3 percent of the threshold speed.

16.2.5 The unit shall provide an output signal with an adjustable duration. The output signal shall be adjustable within the range of 0.5 to 15 seconds in maximum increments of 0.5 second. If a succeeding over-threshold speed is detected prior to expiration of the output, the output timer shall be reset.

16.2.6 The selection of the variable output and the threshold speed shall be accomplished by controls on the front of the unit.

16.2.7 The unit shall be furnished with two (2) inductive loop vehicle detector channels which shall conform to the requirements of Section 5 of these *Specifications*. The detector shall be fully connected to the unit. The unit shall have a power supply for the detector.

16.2.8 The unit shall conform to the "Environmental Requirements" for "Inductive Loop Detectors" set forth in NEMA Standards Publication TS-1.

16.2.9 The unit shall be neither attitude nor position sensitive.

16.2.10 The unit shall be housed in a nonferrous case durably finished with two (2) coats of high quality enamel paint or in a shielded polymer housing having the finish color impregnated in the material.

16.3 PULL (JUNCTION) BOXES

This article covers preformed underground traffic signal pull (junction) boxes, covers and extensions for

roadside applications where occasional exposure to heavy vehicles is anticipated. These units are not intended for roadway or shoulder applications.

16.3.1 Submittal Data

Orthographic drawings with accompanying specification sheets shall be submitted to the Engineer for approval with the submittal data required by Article 1.3 of these *Specifications*. Drawings shall indicate the configuration, dimensions and tolerances of each component. Specification data shall detail the load rating and materials of construction of each component and the assembled enclosure as a whole.

16.3.2 Dimensions and Configuration

16.3.2.1 The pull box inside dimensions shall be a minimum of 445 mm in length, 267 mm in width and 286 mm in depth, excluding the cover mounting boss.

16.3.2.2 Pull box covers shall lie flush with the flanges of their associated pull boxes and be secured by a bolt in each of two (2) diagonally opposite corners. Each cover shall have an imprint of the words TRAFFIC SIGNAL, as shown in the typical drawings, and shall be provided with a pull slot and pin for easy removal.

16.3.2.3 Cover anchor bolts shall be of sufficient length to provide maximum engagement of the threads between the bolt and the nut. The bolt shall be a minimum 9.5 mm outside diameter, hex head. Cover anchor bolt inserts shall be provided with a cleaning port to facilitate maintenance.

16.3.2.4 Vertical extensions for the pull box shall be available within the depth range of 150 mm to 300 mm.

16.3.3 Physical and Chemical Characteristics

16.3.3.1 For ease of handling and installation, no individual enclosure component shall have a mass of more than 21.3 kg.

16.3.3.2 When installed, all exposed enclosure surfaces shall be neutral in color. Color changes caused by environmental exposure are acceptable only if no degradation of the material is indicated and the overall product appearance is not sacrificed.

16.3.3.3 Pull boxes, covers and extensions, excluding hardware, shall be made of non-conductive materials.

16.3.3.4 Pull pins, anchor bolts and associated inserts shall be made of stainless steel.

16.3.3.5 Pull boxes, covers and extensions shall be tested as set forth in paragraph 16.3.4. All

test and control samples shall be taken from finished products.

16.3.3.6 Sample sizes for each test shall be sufficient to assure a minimum test result confidence level of 95 percent. The tests outline in sub-paragraphs A, B, D, E, F, G and H of paragraph 16.3.4 may be made with samples from all components of the pull box assembly prepared in accordance with the appropriate test specification.

16.3.3.7 The tests outlined in subparagraphs A, C and F of paragraph 16.3.4 shall also be performed at -45°C and +60°C.

16.3.3.8 The tests outlined in subparagraphs A, B, D and F of paragraph 16.3.4 shall effect a maximum change of 2 percent in any sample dimension or sample weight.

16.3.3.9 Test samples exposed to the tests described in subparagraphs A, B, D and F of paragraph 16.3.4 shall maintain a minimum of 75 percent of the compressive, tensile, and flexural strengths of their control sample counterparts. These tests shall be conducted in accordance with the test methods cited in subparagraphs G, H, and I of paragraph 16.3.4 respectively.

16.3.3.10 The tests described in subparagraphs A, B, D and F of paragraph 16.3.4 shall effect no visually discernible crazing or cracking of the test samples.

16.3.3.11 The tests outlined in subparagraphs L and M of paragraph 16.3.4 shall be preceded by the application of a pre-load equal to 5 percent of the designated test load. The assembled enclosure shall be subjected to the pre-load for 1 minute and allowed to stand at rest for 1 minute before proceeding with the test. The designated test load shall be applied, held and removed within a 3 minute period. A 1 minute rest period shall precede reapplication of the load. This cycle shall be repeated a minimum of ten (10) times. Deflection under designated test loads shall not exceed 13 mm per meter for the net cover deflection or 21 mm per meter of average box length for vertical load-lateral deflection and lateral load deflection. Permanent deflection shall not exceed 10 percent of the maximum allowable deflection or interfere with cover removal or placement. Upon completion of the test for maximum deflection, the enclosure shall be loaded to the point of failure. The load at failure shall be at least twice the designated test load. The failure type and load at failure shall be defined in the specification data.

16.3.4 Testing

Testing of the pull box components shall be performed as follows.

A. Pull boxes, covers, and extensions with their associated hardware shall be sunlight-resistant and tested in accordance with ASTM G-53 for simulating ultraviolet light and condensation exposure. UV-A 340 lamps shall be used for this test procedure.

B. Pull boxes, covers, and extensions with their associated hardware shall be weather resistant and tested in accordance with ASTM D-756 Procedure E for accelerated service exposure.

C. Each exposed surface of the pull box and cover shall have a static coefficient of friction greater than or equal to 0.5 as determined by ASTM D-1894.

D. Component samples shall have a water absorption ratio of 0.5 percent or less as determined by ASTM D-570.

E. Component samples shall be fire-resistant up to and including resistance to the heat of direct flame. When the heat source is removed, no material shall sustain burning. Fire-resistance tests shall be conducted in accordance with ASTM D-635.

F. Component samples shall be resistant to chemicals commonly found in roadside environments including calcium chloride (10 percent solution), sodium chloride (10 percent solution), acetic acid (5 percent solution), sulfuric acid (0.1 normal solution), antifreeze, hydraulic fluid, brake fluid, motor oil, diesel fuel and gasoline. Chemical resistance tests shall be conducted in accordance with ASTM D-543.

G. Component samples shall have a minimum compressive strength of 75 MPa. Compressive strengths shall be determined in accordance with ASTM C-109 or D-695 as applicable.

H. Component samples shall have a minimum tensile strength of 11.7 MPa. Tensile strengths shall be determined in accordance with ASTM C-496 or D-638 as applicable.

I. Component samples shall have a minimum flexural strength of 51.7 MPa. Flexural strengths shall be determined in accordance with ASTM C-293 or D-790 as applicable.

J. Any point on a component shall withstand a minimum of a 95 J impact administered with a 26.4 kg mass having a Type C tup. Impact resistance shall be determined in accordance with ASTM D-2444.

K. When a cover is installed, a tightening torque of 95 N•m applied to the cover fasteners shall not damage cover fasteners, their associated cover or their associated pull box.

L. Pull boxes, covers and extensions shall be designed for and tested under a minimum vertical load of 9500 kg. The test load shall be distributed by a loading pad. The loading pad shall be a 255 mm x 510 mm x 13 mm thick rubber pad backed by a 255 mm x 510 mm x 25 mm thick steel plate. Load application and removal shall be made in three equal increments. Vertical loading tests shall be performed on assembled enclosures with unsupported sidewalls.

1. The loading pad shall be centered over the enclosure cover and the designated load applied to the center of the pad. Measurements shall be taken to indicate maximum cover deflection under the designated vertical load.
2. The loading pad shall be centered over a long edge of the enclosure. The designated load shall be applied to the center of that portion of the loading pad that is over the enclosure. Measurements shall be taken to indicate the maximum sidewall deflection under the designated vertical load.

M. Pull boxes, covers and extensions shall be designed for and tested under a minimum lateral load of 28.7 kPa. Lateral loading tests shall be performed on an assembled enclosure. The lateral load shall be uniformly distributed and applied along the length of the enclosure to an exterior sidewall. Only the opposing exterior surface shall be supported during this test. Measurements shall be taken to indicate the maximum sidewall deflection under the designated lateral load.

16.3.5 Packing for Shipment

Pull boxes and covers shall be shipped assembled when the quantities ordered are compatible. Orders of extensions shall be shipped on separate pallets from those containing pull box and cover assemblies. Assemblies shall be stacked and strapped on pallets in such a manner that they may be safely shipped and handled by forklift without risk of damage or binding. Overall pallet height shall not exceed 1.8 m. Each pallet shall be readily identifiable by applicable purchase order and requisition numbers without need for unwrapping or package alteration.

16.4 INTERCONNECT CABLE SPLICE ENCLOSURE

All cable splices shall be aerial, in line, and enclosed within a splice enclosure. The splice enclosure shall conform to the following requirements.

16.4.1 The splice enclosure shall be a 100MB/200MB ready access splice enclosure.

16.4.2 The splice enclosure shall be constructed of polyethylene and be capable of accommodating both messenger strand and cable.

16.4.3 The splice enclosure shall have an inner-shield bond and ground system.

16.4.4 The splice enclosure shall be capable of accommodating up to four 6-pair, or one 6- or 12-pair stubbed unprotected, or four 3-pair protected terminal blocks.

16.5 LOOP SLOT SEALANT

Loop slot sealant shall conform to the following requirements.

16.5.2 The sealant shall bond with both asphalt and concrete pavement saw slots to prevent the sealant and the conductors from working out of the slot.

16.5.3 The cured sealant shall protect the conductors by preventing the entrance of water, dirt, rocks, and sticks into the saw slot.

16.5.4 The cured sealant shall be resistant to traffic, water, gasoline, chemical and chemical fumes, mild alkalis, oils and mild acids. Furthermore, in the pre-cured state, the sealant shall not be affected by water.

16.5.5 No noticeable deterioration of the sealant shall be apparent after exposures to temperatures within the range of -40 to 73°C.

16.5.6 The sealant shall not chemically interact with the loop wire insulation or pavement. The sealant shall not generate temperatures in excess of 105°C during its curing or settling process.

16.5.7 The sealant shall have sufficient flexibility to permit expected pavement expansion and contraction due to weather and to permit pavement movement due to traffic without cracking at all temperatures from -40 to 73°C.

16.5.8 The sealant shall be self leveling, but shall have sufficient viscosity to prevent exit from the saw slot when installed on a 10 percent grade.

16.5.9 The sealant shall dry to a tack free state in two (2) hours or less.

16.5.10 When installed according to the manufacturers instructions, the sealant shall not flow within the slot or flow out of the slot after exposed surface has become tack free.

16.5.11 The sealant shall have a usable life, once mixed (if more than one (1) component), of at least 10 minutes when the ambient temperature is 25°C.

16.5.12 A two-part sealant shall cure sufficiently within 48 hours to attain 95% of its published

properties for cured material. A one-part sealant shall cure sufficiently within 30 days to achieve 95% of its published properties for cured material.

16.6 BACKER ROD

Backer rod may be installed in traffic signal loop slots between the loop wires and slot sealant when specified. The backer rod shall conform to the following requirements.

16.6.1 9.5 mm diameter backer rod shall be installed over the inductive loops in a loop slot by pressing the rod uniformly into the joint with a blunt tool or roller.

16.6.2 The backer rod shall be chemically inert, and resistant to oils, gasoline, and solvents.

16.6.3 The backer rod shall be round, flexible, and be installed with one continuous length.

16.6.4 The backer rod shall be composed of a closed-cell polyethylene foam.

16.6.5 The backer rod shall conform to the requirements of ASTM D 5249-92.

16.7 TRAFFIC SIGNAL LAMPS

This article sets forth the requirements for traffic signal lamps for both 200 mm and 300 mm vehicular traffic signal sections and both 225 mm and 300 mm pedestrian traffic signal sections. Traffic signal lamps shall be furnished as required by the bid list or the plans and shall conform to the requirements of the "Traffic Signal Lamps" section of the *Equipment and Materials Standards of the Institute of Transportation Engineer* (ITE Standards), unless otherwise noted, and to the following requirements.

16.7.1 Incandescent Lamps for Standard (Non-Programmed) Signals

Incandescent lamps for standard (non-optically programmed) traffic signals shall conform to the following requirements.

16.7.1.1 Each lamp shall have a rated operating voltage of 130 volts AC.

16.7.1.2 Each lamp shall have a rated life of not less than 8,000 hours when operated at rated voltage under the design conditions set forth in paragraph 16.6.1.1.

16.7.1.3 Each lamp shall have the indicated wattage and rated initial lumen output for its application as follows:

SIGNAL SECTION	WATTAGE	LUMEN OUTPUT
200 mm vehicle signal	90	1040
300 mm vehicle signal	135	1750
300 mm pedestrian signal	90	1040

The lumen output of the lamp shall not be less than 80 percent of the above value at the

rated life of the lamp.

16.7.1.4 Certification from the lamp manufacturer shall be provided to the City stating that all lamps conform to these *Specifications*.

16.7.2 Lamps for Optically Programmed Signals

Lamps for optically programmed traffic signals shall conform to the following requirements.

16.7.2.1 Each lamp shall be designed to be fully compatible with the signal section in which it will be used.

16.7.2.2 Each lamp shall have a rated operating voltage of 120 volts AC.

16.7.2.3 Each lamp shall have a rated life of not less than 6,000 hours when operated at rated voltage under the design conditions.

16.7.2.4 Lamps for use in 300 mm optically programmed signal sections shall provide 950 beam candela (150-watt) in a Parabolic Annular Reflector 46 envelope.

16.7.2.5 Certification from the lamp manufacturer shall be provided to the City stating that all lamps conform to these *Specifications*.

16.7.3 Illuminating Elements for Special Traffic Signal Sections

Illuminating elements for other than standard incandescent traffic signal sections or standard optically programmed traffic signal sections shall conform to the recommendations of the traffic signal section's manufacturer. All such elements shall have a rated life of at least 6,000 hours at a rated voltage of 120 volts AC.

16.7.4 LED Lamps for Standard (Non-Programmed) Signals

LED lamps for standard (non-optically programmed) traffic signals shall conform to the requirements of Section 14.1.3.5 of these specifications.

16.8 CONDUIT

Conduit and related boxes and fittings required by the bid form or the plans shall conform to the following requirements and shall be of the type and sizes required by said documents.

16.8.1 Metallic Conduit

Metallic conduit shall be rigid galvanized steel conduit meeting the requirements of UL Standard 6, "Rigid Metallic Conduit", with rigid full-weight sherardized or galvanized

fittings. Metallic conduit shall be used for all above ground applications, unless otherwise specified.

16.8.2 Non-Metallic Conduit

16.8.2.1 PVC Conduit

PVC conduit shall be rigid polyvinyl chloride (PVC) heavy wall conduit approved for underground use without concrete encasement in accordance with UL Standard 651, Schedule 40 (for underground use only) or schedule 80. When PVC conduit is specified for above ground use, UL Standard 651, schedule 80 PVC shall be used.

16.8.2.2 Polyethylene Conduit

Polyethylene conduit shall be low-friction, coilable, high-density conduit conforming to the following requirements.

A. The conduit shall be manufactured of virgin high-density polyethylene.

B. The conduit shall have smooth walls.

C. The conduit shall be capable of being coiled on reels in continuous lengths, transported, stored outdoors and subsequently uncoiled for installation without affecting its properties or performance.

D. The conduit shall be suitable for underground use in an ambient temperature range of -35 to +55°C without degradation of material properties.

E. The conduit shall be resistant to benzene, calcium chloride, ethyl alcohol, fuel oil, gasoline, lubricating oil, potassium chloride, sodium chloride, sodium nitrate and transformer oil. It shall be protected against degradation due to oxidation and general corrosion.

F. It shall be possible to bend the conduit to a minimum supported radius of ten (10) outside diameters.

G. The open ends of each length of conduit shall be sealed to prevent the entrance of dirt and moisture.

H. The conduit shall be furnished in the lengths and diameters specified on the plans or the bid list.

I. The conduit shall be of the nominal size required by the plans or the bid list. The outside diameter and the wall thickness shall correspond to Standard Dimension Ratio (SDR) 13.5 as stated in ASTM-D3035.

J. The conduit shall be factory-lubricated to aid in the installation of wires and cables.

K. The conduit shall be equipped with a factory-installed rope having a nominal

tensile strength of 11 kN to aid in the installation of wires and cables.

L. The conduit shall satisfy the following ASTM requirements.

ASTM-D638	
Tensile strength	20MPa, minimum
Elongation	400 percent, minimum
ASTM-D1238	
Melt index	0.4 maximum
ASTM-D1505	
Density	0.941 - 0.955 g/cc
ASTM-D1693	
Condition B	20 percent failure, maximum
ASTM-D2444	
Impact	Per NEMA Standards Publication No. TC7
ASTM-D3350	
Cell classification	334420 or 344420

16.8.3 Flexible Conduit

Flexible conduit shall be liquid-tight metallic conduit meeting the requirements of UL Standard 360, "Liquid-Tight Flexible Steel Conduit, Electrical", acceptable for equipment grounding; and with insulated throat, grounding, malleable iron watertight fittings.

16.8.4 Conduit Boxes and Fittings

Conduit boxes and fittings shall be watertight galvanized steel or Schedule 80 PVC meeting the requirements of UL Standard 514B, "Fittings for Conduit and Outlet Boxes".

16.9 AUDIBLE PEDESTRIAN SIGNALS

Audible pedestrian signals are devices that issue two (2) distinct audible signals for the control of visually impaired pedestrians. Audible pedestrian signals shall conform to the following requirements.

16.9.1 Function Requirements

Audible pedestrian signals shall conform to the following functional requirements.

16.9.1.1 Each audible pedestrian signal shall provide two (2) distinct signals, one (1) for the control of pedestrians crossing the North-South (NS) street and one (1) for the control of pedestrians crossing the East-West (EW) street. Selection of the appropriate signal

shall be by means of a jumper or a switch inside the unit.

16.9.1.2 One (1) of the signals, Signal NS, shall have a duration of 0.6 seconds ± 20 percent and shall be derived from the combination of two (2) frequencies: 1,100 Hz ± 20 percent and 1,220 Hz ± 20 percent. The signal shall be repeated at the rate of 40 times per minute. The combination of tones shall generate a cuckoo sound.

16.9.1.3 The other signal, Signal EW, shall have a duration of 0.2 seconds ±20 percent and shall be derived from the combination of two (2) frequencies: 2,800 Hz 20 percent and 2,000 Hz ± 20 percent. The signal shall be repeated at the rate of 60 times per minute. The combination of tones shall generate a chirping sound.

16.9.1.4 A volume control shall be provided inside the unit. Use of a screwdriver will be acceptable for adjusting the volume.

16.9.1.5 The base audio output level for each signal shall be at least 90 dB at 1 W/m. An automatic level control (ALC) circuit shall be provided to automatically monitor ambient noise at the intersection. Based on the volume control setting, the ALC shall maintain the proper signal-to-noise ratio for clear audible recognition.

16.9.1.6 The input for each signal shall be 115 volts ± 15 percent, 60 Hz.

16.9.1.7 Power consumption shall not exceed 4 watts per input.

16.9.1.8 The audible pedestrian signal shall operate properly when the ambient temperature is within the range of -37 and +74°C and the humidity is within the range of 5 to 95 percent relative humidity.

16.9.1.9 The audible pedestrian signal shall be suitable for use outdoors without requiring a cover or housing.

16.9.2 Physical Requirements

Audible pedestrian signals shall conform to the following physical requirements.

16.9.2.1 The audible pedestrian signal dimensions shall not exceed 150 mm high x 100 mm wide x 150 mm deep, excluding mounting hardware.

16.9.2.2 The mass of the audible pedestrian signal head shall not exceed 4.5 kg.

16.9.2.3 The audible pedestrian signal shall have a hole in the bottom that is suitable for the entrance of a standard 25 mm conduit. This hole shall be adequate to accommodate both mounting of the unit and entrance of the electrical cable. Alternatively, an

adjustable mounting shall be provided which shall serve as the mounting device and the conduit. The adjustable mounting shall provide a positive means of locking the signal in the proper position.

16.9.2.4 The audible pedestrian signal shall be enclosed in a shielded, high-impact polymer or non-ferrous housing.

16.10 MICROLOOP SENSOR

This article of the *Specifications* sets forth the requirements for microloop sensors for use with the inductive loop detectors specified in Section 5. The microloop sensors shall conform to the following requirements.

16.10.1 The sensor shall be suitable for imbedding in pavement for the purpose of detecting vehicles when connected to the inductive loop detectors specified in Section 5.

16.10.2 The sensor shall be a cylindrical transducer that converts magnetic field intensity into inductance.

16.10.3 The sensor shall have maximum dimensions of 23 mm in diameter and 100 mm in length. It shall install in a 25 mm hole.

16.10.4 The sensor shall provide a field strength in the range of 15.9 to 791 A/m.

16.10.5 The inductance of the sensor shall be 20 microhenrys plus 20 microhenrys per 30 meters of lead-in cable.

16.10.6 The DC resistance of the sensor shall be 0.5 ohm plus 3.2 ohms per 30 meters of lead-in cable.

16.10.7 The sensor shall operate properly when the ambient temperature is within the range of -37° to +74°C and the ambient relative humidity is within the range of 0 percent to 100 percent.

16.10.8 The sensor shall operate properly even when submerged in solutions of chemicals typically found in roadway runoff.

16.10.9 The sensor shall be furnished with the lead-in cable permanently connected to it. The amount of lead-in cable shall conform to the requirements of the plans or the bid list. The lead-in cable shall have four (4) A.W.G. #22 conductors and shall have a maximum outside diameter of 5 mm.

16.11 WOOD POLES

Wood poles shall be structural timber as defined in the *Standard Specifications*. Poles shall be treated with chromated copper arsenate to a minimum of 31.5 kg/m^3. Poles shall be 10.5m, class 5 unless otherwise specified in the plans.

16.12 MICROWAVE DETECTORS

This article sets forth the minimum requirements for sidemount and overhead mount Microwave vehicle detectors.

16.12.1 The detector shall be capable of detecting motion of every type of vehicle including mopeds and be capable of funtioning in either a sidemount position or an overhead position.

16.12.2 The range of the detector shall be from 1m to 30m and the detector shall have a 16 degree field of view.

16.12.3 The detector shall have an adjustment for range and an adjustment for time delay extension.

16.12.4 The detector shall meet all applicable F.C.C. rules and be capable of operating from 10V AC to 24V AC and also at 12V DC.

16.12.5 The detector shall be encased in a finished fabricated aluminum, water resistant case capable of continuos operation over a temperature range of -35°F to 165°F.

16.13 CAMERAS

This article sets forth the minimum requirements for cameras used for general observational purposes and for cameras to be used in conjunction with machine vision detection.

16.13.1 Machine Vision Detection Cameras

16.13.1.1 The camera shall be capable of operating on 115 VAC or 220 VAC.

16.13.1.2 The camera housing shall be sealed to prevent entry of moisture, sand, dust or other contaminents.

16.13.1.3 The camera housing shall have a sunshield that includes a cradle to allow rotation of sunshield with respect to the housing.

16.13.1.4 The camera shall come with an internal heater for icing conditions and shall be capable of operating in temperature ranges from -40°C to 160°C.

16.13.2 General Observation Cameras

16.13.2.1 The general observation camera shall meet the requirements of Article 16.13.1 as well as be capable of pan, tilt, and zoom operations.

SECTION 17
INSTALLATION AND CONSTRUCTION

17.1 GENERAL

This section of the *Specifications* sets forth the requirements for the on-site installation and construction work related to installing the traffic control equipment. All such installation and construction work shall conform to the following requirements and to the requirements of the typical drawings, unless otherwise specifically noted. The requirements of Section 1 apply to work and material provided under this Section. Whenever equipment or materials must be furnished, said equipment and materials shall conform to the applicable requirements of Sections 2 through 16.

17.2 ELECTRICAL AND WIRING REQUIREMENTS

The following electrical and wiring requirements shall apply to all work under these specifications. All electrical equipment shall be fabricated and connected in accordance with the *National Electrical Cod*e published by the National Fire Protection Association and with all State and City codes.

17.2.1 Grounding and the *National Electrical Code*

17.2.1.1 All equipment, housings, cabinets, pedestals and metal poles shall be grounded and bonded in accordance with the *National Electrical Code*. Pedestrian push-buttons are included in this item.

17.2.1.2 All metallic conduit shall be grounded and bonded in accordance with the *National Electrical Code*.

17.2.1.3 All grounding electrodes shall be of copper clad steel rod at least 3.05m in length, having a diameter of at least 15.87mm, and be driven into undisturbed earth to a point such that no more than 100mm of the rod will be exposed above the cabinet base or ground.

17.2.2 Wiring Requirements

17.2.2.1 All wire, cable, connectors, and other incidental materials necessary to connect all new equipment and all existing equipment shall be installed to form a fully functional and properly operating installation and system. Existing wire or cable which is damaged or too short shall be replaced with proper type and size as required by these *Specifications*.

17.2.2.2 All splices will be made in-line with approved connections.

17.2.2.3 Cable which is to be attached to a messenger cable shall be attached using 1.14 mm (minimum) diameter galvanized steel spiral cable lashing. Cable shall be lashed to the messenger cable at a rate of 1 revolution every 330 linear millimeters.All cable attached to messenger cable shall be pulled tight and lashed closely to the cable so that the combined installation of the messenger cable and the various cables attached to it appear to be one integral cable. There shall be no gaps between the various cables and the messenger cable.

17.2.2.4 Electric service conductors shall not be exposed or installed in the same conduits, raceways or pull boxes with other conductors or fiber optic cables.

17.2.2.5 The ends of all conductors which are to be attached to screw-type terminal blocks shall be provided with solderless lugs that meet the requirements of the *National Electrical Code*, that are sized to match the conductors and the terminal screws, and are of the - insulated positive-grip type. The lugs shall be installed on the conductors with an approved terminal crimping tool. The terminal crimping tool shall produce a transverse crimp on the wire.

17.2.2.6 All wire and cable entrances into conduit weatherheads, signal heads, and holes in mast arms, pedestals and poles shall be made via insulating bushings.

17.2.2.7 Wiring within control equipment cabinets and pull boxes shall be cabled together with self-clinching nylon cable ties, waxed lacing or other method approved by the Engineer.

17.2.3 Signal Equipment Cabinet Grounding

17.2.3.1 A grounding electrode shall be installed at each new cabinet installation. These electrodes shall be permanently connected to the grounding electrode at the pole with solid #4 AWG copper ground wire.

17.2.3.2 Grounding conductors (ground wires) used for connecting the grounding electrode(s) together and to a signal equipment cabinet ground bus, metallic conduits, or pedestals shall be solid copper wire or strap having a cross-sectional area at least as great as A.W.G. #4 wire.

17.2.3.3 Connections between grounding electrodes and the grounding conductors shall be by exothermic weld.

17.2.3.4 Grounding shall be accomplished by bonding the cabinet grounding circuits to grounding electrodes. Maximum resistance between the grounding electrode and any point in the cabinet grounding system shall not exceed five (5) ohms.

17.2.3.5 The grounding system shall be tested at the connection point to the cabinet ground bus using an approved test method. The ground system shall measure a maximum of 20 ohms. Additional ground rods shall be connected to the system to improve conformance with the test results as per the Engineer.

17.2.3.6 Connections to underground metallic conduits or down guys shall not be deemed sufficient for grounding purposes.

17.2.3.7 The ground bus in each control equipment cabinet shall be permanently connected to the grounding electrode by a A.W.G. #4 (minimum) ground wire. The power company neutral shall be connected to the AC common bus in the cabinet. The AC common bus shall be connected to the cabinet earth ground bus at the service entrance. All conduits and equipment grounds shall be connected to the cabinet earth ground bus and grounding electrode.

17.2.4 Grounding and Bonding of Signal Poles

17.2.4.1 *NEC* Compliance

All work shall be in compliance with the *National Electrical Code*.

17.2.4.2 Materials

All grounding electrodes shall be 3.05 m copper clad steel rod having a diameter of at least 15.87 mm. Grounding conductors used for jumpers and for connecting the grounding electrode(s) to metallic conduits, metal poles and pedestals, and messenger cable shall be A.W.G. #4 solid copper wire or strap having a cross-sectional area at least as great as A.W.G. #4 wire. Stranded wire may be run in conduit only.

17.2.4.3 Continuity of Metallic Objects

Metallic cable sheaths, metallic conduit, transformer bases, anchor bolts, metal poles and pedestals shall be made mechanically and electrically secure to form a continuous electrical system and shall be effectively grounded.

17.2.4.4 Wood Poles

Each wood pole used in a signal installation shall have a ground wire installed in such a manner as to minimize damage to the wire from natural abuse and vandalism. This ground wire shall be A.W.G. #4 (minimum) copper wire bonded to a new grounding electrode. The ground wire shall extend up the pole to a point adjacent to the uppermost span. Wire staples, with a 300 mm maximum spacing from ground level to at

least 2.4 m above ground and a 600 mm maximum spacing above 2.4 m, shall be used to secure the wire to the pole.

17.2.4.5 Metal Poles

Each metal pole used in a signal installation shall be grounded as shown in the typical drawings. Should existing poles be used that do not have a grounding electrode, a new grounding electrode shall be driven. All protective finish shall be removed from the pole in the area of attachment. The resistance from any point on the pole to the grounding electrode shall not exceed 5 ohms.

17.2.4.6 Joint-Use Poles

Joint-use poles shall contain a separate grounding system for signal equipment and hardware. The grounding system(s) owned by other users of the pole shall not be used under any circumstances.

17.2.4.7 Grounding Electrodes Required

A grounding electrode shall be installed at each new pole. An existing grounding electrode may be used at an existing pole if the resistance of the grounding system to ground is 20 ohms or less.

17.2.4.8 Bonding Requirements

All span wires, conduits, down guys, pedestrian signals, and pedestrian detectors shall be bonded to the pole ground using split-bolt connectors or approved equivalents. Connections between messenger cables and the ground wire shall be by a listed, screw-type, positive locking bonding clamp. No snap-on connections shall be permitted. Maximum resistance between the grounding electrode and any point in the grounding system shall not exceed 5 ohms. Connections to underground metallic conduits or down guys shall not be deemed sufficient for grounding purposes.

17.2.4.9 Connections between grounding electrodes and the grounding conductors shall be by mechanical means with an approved connection.

17.2.4.10 Bonding Multiple Span Wires or Messengers

All multiple span wire arrangements shall be connected at the corners with A.W.G. #4 copper wire and bonded with split-bolt connectors

17.3 GENERAL SITE WORK

General site work shall conform to the requirements of the *Standard Specifications* and to the following requirements.

17.3.1 Protection of Utilities

All present utilities, including traffic signals and their related equipment and detectors, that have been located by the various utility owners shall be protected from damage during the work. All of the utility companies and agencies known to be affected by the work shall be contacted to verify the location of existing utilities. Damaged utilities which have been located by the owner shall be repaired and replaced. The party damaging the utility shall be responsible for notifying the owner, arranging for repair, and bearing the expense of these repairs.

17.3.2 Excavating and Backfilling

17.3.2.1 Excavations required for the installation of conduit, foundations and other equipment shall be performed so as to cause the least possible damage to the streets, sidewalks, and other improvements. However, such excavations shall be sufficiently wide to permit effective repair of the pavement, sidewalks and improvements in a manner which will not require excessive maintenance. All such excavations shall be made in accordance with the typical drawings. Trenches shall not be wider than necessary for the proper installation of the equipment, materials or foundations.

17.3.2.2 Excavations shall not be started until the equipment or materials to be installed are on site and ready to be installed.

17.3.2.3 The material from the excavation shall be located so that the disruption to vehicular and pedestrian traffic is minimized and so that interference with surface drainage will not occur.

17.3.2.4 Excavations shall be backfilled and compacted to at least the density of surrounding material to the satisfaction of the Engineer. Backfill shall be tamped with mechanical tamps in 150 mm (maximum) fill depths or lifts. All materials necessary for backfilling and finishing the excavations shall be installed.

17.3.2.5 When excavations are made in a street or highway and the base material is disturbed, restoration will be made in accordance with the procedures outlined in CDOT's

Regulations and Fee Schedule Procedures for Closing Asphalt and Concrete Pavements.

17.3.3 Site Restoration

17.3.3.1 Roadway Surfaces, Curbs/Curbs and Gutters, Driveway Aprons, and Sidewalks

When it becomes necessary to excavate roadway surfaces, curbs/curbs and gutters, driveway aprons, or sidewalks, then the Contractor is responsible for following the procedures outlined in CDOT's *Regulations and Fee Schedule Procedures for Closing Asphalt and Concrete Pavements*. Copies may be obtained by calling (704) 336-2930.

17.3.3.2 Walls

Walls which are damaged by the operations shall be restored in a manner approved by the Engineer in each instance. Care shall be taken to match the material and construction of the restoration with that of the original wall so that the fact the damage occurred will be unnoticeable to the extent practical.

17.3.3.3 Grassed Areas

All grassed areas disturbed by the operations shall be restored to their original levels and contours. In restoring such areas, the top 40 mm of soil shall be raked to render it free of large stones and debris and make it suitable for seeding or sodding. All areas shall be seeded with K-31 fescue per NCDOT specifications unless otherwise specified.

17.3.4 Protection of Underground Buildings

Some buildings may extend under the sidewalks and streets. Before beginning any excavation work, verify that excavations will not damage any underground building.

17.3.5 Protection of Existing Detection

Existing traffic signal detectors shall remain in operation. Loops, detector elements and lead-in cables which are damaged by the operations shall be replaced in a manner which is satisfactory to the Engineer and at no cost to the City. Prior to beginning work, verify the existence and working order of traffic detection systems and bring to the attention of the Engineer any which are not in working order or which are damaged.

17.3.6 Removal of Excess Material

All excess material shall be removed from the site and disposed of in accordance with the *Standard Specifications*.

17.4 CONCRETE

All concrete needed for the proper installation of the work shall be installed in accordance with the typical drawings, the plans and the other contract documents. Unless otherwise specifically noted in each instance, all concrete used in the work shall satisfy the requirements for Class "B" concrete as set forth in the *Standard Specifications*.

17.5 CONDUIT AND PULL (JUNCTION) BOXES

Conduit and pull (junction) boxes shall be installed in accordance with the following requirements.

17.5.1 All conduit and all pull boxes necessary to complete the work shall be installed in accordance with the typical drawings, the plans and the other contract documents. Conduit shall conform to the requirements of these *Specifications*. Each length of conduit shall be true to size and form and shall be free from warps, kinks and bends, except the bends required to fulfill the requirements of the plans.

17.5.2 Larger size conduit than that shown on the plans or typical drawings may be used, if approved by the Engineer. Where larger size is used, it shall be for the entire length of the run from termination point to termination point. Reducing couplings shall not be permitted.

17.5.3 Bends shall be of uniform curvature and the inside radius of curvature of any bend shall not be less than six (6) times the internal diameter of the conduit. Bends shall be made so that the conduit will not be damaged or its internal diameter changed.

17.5.4 Bends and conduit elbows shall have sufficient radii to accommodate the minimum bending radii of the wire and cables to be installed in them.

17.5.6 Conduit runs shown in the plans may be changed, if approved by the Engineer.

17.5.7 To the extent practical, conduit runs shall be combined in the same trench to minimize the amount of trenching and backfilling.

17.5.8 Underground conduit shall be placed at a minimum depth of 450 mm below finish grade or 150 mm below roadway subgrade, whichever is deeper.

17.5.9 All metallic conduit ends shall be threaded in accordance with NEC specifications for rigid metal conduit.

17.5.10 All conduits shall be capped with standard end caps until wiring is started. When caps are removed, the threaded ends of metallic conduits shall be provided with approved

conduit bushings and the ends of non-metallic conduit shall be provided with bell ends.

17.5.11 The threads on all steel pipe conduit shall be painted with zinc rich paint and allowed to dry before couplings are made up. A waterproofing compound shall be applied to all joints before coupling.

17.5.12 Where the galvanized finish on conduit has been damaged in handling, it shall be repaired in accordance with the section on "Galvanizing" in the *Standard Specifications*. Ungalvanized conduit stubs, caps, and exposed threads on ferrous metal type conduit resulting from field cuts shall be painted with two (2) coats of zinc-rich paint.

17.5.13 All couplings shall be tightened until the ends of conduits are brought together so that an electrical connection will be made throughout the entire length of the conduit run.

17.5.14 Conduit buried in open trenches parallel to a roadway shall be placed a minimum of 300 mm from the back of curb or, in the absence of curb, a minimum of 1.8 m from the edge of pavement, unless otherwise shown on the plans or directed by the Engineer.

17.5.15 Unless otherwise required by the plans or the Project Special Provisions, open trench methods of placing conduit will be permitted except where the conduit is to be placed under existing concrete pavement or a railroad. If it is determined by the Engineer that it is impractical to jack or bore the conduit under concrete pavement or at other locations required by the plans due to unforeseeable obstructions, with the Engineer's permission, an open cut may be used.

17.5.16 When conduit must be installed without trenching, approved jacking or boring methods shall be used. Water jetting shall not be permitted. Pits for jacking or boring shall not be closer than 600 mm to the back of curb or the edge of pavement, in the absence of a curb, unless otherwise directed by the Engineer.

17.5.17 Underground conduits shall be installed at least 160 mm from any utility line, unless otherwise allowed by the Engineer.

17.5.18 Conduit terminating in metal poles or pedestal bases shall be sloped toward the handhole openings.

17.5.19 Conduit entering foundations and manholes shall enter from the direction of the run and shall be sloped to facilitate pulling cable.

17.5.20 A 10 mm braided nylon cord having a nominal tensile strength of 11 kN, or approved equivalent, shall be installed in all conduit which the plans or the Project Special Provisions indicate is to receive cable to be installed by others or which is to be left otherwise empty. At least 600 mm of pull wire shall be doubled back into the conduit at each termination.

17.5.21 Expansion fittings shall be installed where conduit crosses expansion joints in concrete structures. Each section of metallic conduit at an expansion joint shall be bonded by a method listed by Underwriters Laboratory for use with that expansion fitting or with an A.W.G. #6 copper wire jumper.

17.5.22 All conduit runs shall be free of moisture, trash, and debris before wire or cable is pulled.

17.5.23 Where conduit must be installed transversely across sidewalks,stairs, or other structures which are 3 m or less wide, the installations shall be made by simple (not jacking and boring) boring techniques without cutting the sidewalks or stairs. Simple borings will be paid at the per meter rate for open trenching.

17.5.24 Conduit which is installed essentially parallel with the roadway or sidewalk shall be installed by trenching, unless otherwise noted; however, with the approval of the Engineer, such conduit may be installed by jacking and boring.

17.5.25 For purposes of conduit installation, driveways shall be considered as part of the sidewalks or sidewalk areas which they cross.

17.5.26 Conduits entering concrete foundations for poles, pedestals or control equipment cabinets shall extend approximately 100 mm above the foundations. Conduits entering pull boxes shall extend approximately 100 mm above the crushed stone base of the pull box, provided that the cables and wires shall not touch the pull box cover.

17.5.27 The open ends of all outside vertical conduits which are exposed to rain shall be equipped with weatherheads. This requirement does not apply to conduit which houses only a grounding conductor for a pole.

17.5.28 As part of the installation of conduit, pull (junction) boxes shall be installed as shown on the plans. With the approval of the Engineer, additional pull boxes may be installed to facilitate the work of installing conduit and pulling wires and cable. When subjected to traffic loads, adequately designed precast concrete or cast iron pull boxes shall be allowed if, in the opinion of the Engineer, the subgrade has sufficient bearing qualities to adequately support the pull box under the traffic load. When the subgrade does not

have sufficient bearing capacity, cast-in-place concrete foundations acceptable to the Engineer shall be formed and allowed to set before forms are removed. The foundations shall conform to the requirements of the "Incidental Concrete Construction - General" and "Foundation Excavation" sections of the *NCDOT Standard Specifications*.

17.5.29 In some cases, installation of conduit into existing pull boxes will be required. In such cases, the completed installation shall be in accordance with the requirements of Paragraphs 17.5.29 and 17.5.31.

17.5.30 Wherever pull (junction) boxes are required, the pull boxes shall be installed in accordance with the typical drawings, installing all crushed stone and other incidental items required to complete the work. Pull boxes shall conform to the requirements of Article 16.3.

17.5.31 All pull box covers shall be bolted to the pull box.

17.5.32 After placement of the conduit, the trench shall be backfilled and restored as required by Paragraphs 17.3.2 and 17.3.3.

17.5.33 Following the backfilling, all conduits shall be tested and cleaned.Testing shall be by means of a mandrel having an outside diameter of 6 mm less than the inside diameter of the conduit and a length of at least 50 mm. Any conduit which fails this test shall be replaced and retested.

17.5.34 As required by the plans, pull boxes which are no longer needed shall be removed and the surface shall be restored as described under Paragraph 17.3.3, installing all necessary materials.

17.6 EQUIPMENT INSTALLATION

When the work requires the installation of traffic control equipment, the equipment shall be installed in accordance with this article of the *Specifications* and the typical drawings. Unless otherwise specifically noted in each instance, all necessary materials and equipment shall be installed to effect a complete and totally operational traffic signal. This includes, but is not limited to, anchor bolts and other mounting hardware, wire, cable, connectors, conduit and associated fittings, concrete, grounding electrodes and grounding conductors, studs, and other items necessary to the installations.

17.6.1 Foundations

Foundations for control equipment cabinets, poles and pedestals shall be installed as required by the typical drawings and the plans in accordance with the following requirements and the requirements of the "Incidental Concrete Construction -General" and the "Foundation Excavation" sections of the *NCDOT Standard Specifications*.

17.6.1.1 The Engineer shall be informed when the excavation is complete. No concrete shall be poured until the Engineer has approved the excavation for each individual foundation.

17.6.1.2 No foundation shall be placed over any uncompacted fill or muck except with the approval of the Engineer.

17.6.1.3 The use of forms shall not be permitted except when the foundation is above ground level. When forms are used, they shall be true to line and grade and securely braced in place and approved by the Engineer prior to pouring. Tops of foundations shall be finished to the grade shown on the plans or typical drawings or to the curb or sidewalk grade as directed by the Engineer.

17.6.1.5 Anchor bolts with leveling nuts and locking nuts shall conform to the provisions in Sections 12 and 13 of these *Specifications*. Anchor bolts shall be set to provide the pole and mast arm orientation required by the plan(s) or typical drawings using a template or detailed drawing furnished by the associated pole, pedestal or cabinet manufacturer.

17.6.1.6 All concrete foundations for poles and pedestals shall be allowed to set for at least seven (7) days before any structures are installed thereon. This period may be reduced to 72 hours when high early-strength concrete is used. Foundations for base-mounted control equipment cabinets shall be allowed to set for at least 72 hours before placement of the cabinets. This period may be reduced to 24 hours when high early-strength concrete is used.

17.6.1.7 All necessary reinforcing steel shall be installed in accordance with the typical drawings and the plans.

17.6.1.8 Foundations shall be monolithic with the exposed surfaces formed and finished to present a neat, smooth appearance. The tops of all foundations for poles and pedestals shall be exactly level for proper mounting of the poles and pedestals. The bottom of each foundation shall rest on undisturbed earth.

17.6.1.9 A copper clad steel grounding electrode with a diameter of at least 15.87 mm shall be installed in each foundation. The grounding electrode shall be installed, as shown in the typical drawings, so that it extends into the surrounding undisturbed earth from the side

or bottom of the foundation for a minimum of 2.44 m. The grounding electrode shall be driven into place. Unless otherwise noted, the grounding electrode shall extend 75 mm above the foundation. The location of the grounding electrode shall not interfere with the entry, dressing or connection of cables.

17.6.1.10 Forms for the concrete shall be rigid and securely braced in place. Templates shall be used to properly position and hold in place necessary conduits, anchor bolts and the grounding electrode.

17.6.2 Control Equipment Cabinets

Control equipment cabinets, when included in the contract, shall be installed in accordance with the following requirements.

17.6.2.1 Control equipment cabinets and associated equipment shall be installed in accordance with the typical drawings and the plans to form a fully functional system. Such installation shall include:

- Installation of the electrical service;
- Conduits for wires and cables entering the cabinet;
- Installation of all wire and cable;
- Connection of the cabinet and its equipment to the power source, and all new signals, detectors, signal systems and other devices;
- Connection of the cabinet and its equipment to all existing signals, detectors, signal systems and other devices which are to remain;
- Installation of all required equipment in the cabinet;
- Installation of all mounting hardware; and
- Set up and timing of all of the equipment in the cabinet using timings and settings which are shown on the plans or which have been furnished by the City.

17.6.2.2 When installing an electrical service, obtain the electric meter base from the City.

17.6.2.3 If the cabinet to be installed is a ground-mounted or pedestal-mounted cabinet, a foundation shall be installed in accordance with paragraph 17.6.1 and the standard drawings of the *Specifications*, unless otherwise noted.

17.6.2.4 All detectors shall be labeled with their associated loop or sensor number and phase identification.

17.6.3 Poles, Mast Arms and Signal Pedestals

Signal pedestals, poles and mast arms, when included in the contract, shall be installed in accordance with requirements of the typical drawings, the plans and the following requirements.

17.6.3.1 Wood Poles

A. A hole that will allow adequate compaction of the earth after placement of the wood pole shall be drilled or augured.

B. After placement of the pole, the hole shall be backfilled with the excavated material and the material shall be compacted to a density at least equivalent to that of the surrounding material. Compaction shall be performed in lifts that do not exceed 150 mm in depth.

C. The wood pole shall be installed so that the pole is within 2 degrees of vertical when loaded with the suspension spans, signals and signs shown on the plans.

D. All unbalanced loads imposed by the suspensions attached to the poles shall be guyed as shown in the typical drawings and the plans and in accordance with paragraph 17.7.2.

E. The pole, the span wires, the guys and the messenger cables shall be grounded to the grounding electrode and the intersection grounding system, installing all needed grounding electrodes, ground wire and associated hardware as shown in the typical drawings.

F. The pole shall be set at the depth recommended by the manufacturer.

17.6.3.2 Mast Arm Poles, Strain Poles and Mast Arms

A. The poles and mast arms shall be installed so that the pole is within 2 degrees of vertical, and the arms, if of horizontal-type, are within 2 degrees of horizontal and within 2 degrees of the horizontal orientation shown on the plans when loaded with the suspension spans, signals and signs shown on the plans. Strain and mast arm poles shall be installed with the proper "rake" as recommended by the associated manufacturers to assure proper set when the load is applied. Threaded leveling nuts shall be used to establish the rake. The use of shims or other leveling devices shall not be permitted. Hardware and fittings shall be installed as shown on the manufacturer's installation drawings.

B. The pole shall be connected to the grounding electrode and the intersection grounding system.

17.6.3.3 Signal Pedestals

A. The pedestal shall be installed so that it is within 1 degree of vertical.

B. The pedestal shall be connected to the grounding electrode and the intersection grounding system.

17.6.4 Signal Heads

Signal heads, both vehicular and pedestrian, including blank-out and changeable message signs, shall be installed with all appropriate mounting hardware, in accordance with the plans, the typical drawings and the following requirements.

17.6.4.1 Vehicular and pedestrian signal heads shall be covered in a manner acceptable to the Engineer until the intersection is placed in operation.

17.6.4.2 Each signal face shall be adjusted vertically and horizontally so that its light output will be of maximum effectiveness to the approaching traffic for which it is intended. The signal faces shall not be tilted forward unless otherwise directed by the Engineer. See typical installation drawings.

17.6.5 Pedestrian Push-Buttons and Related Items

Pedestrian push-buttons and related items shall be installed as required in accordance with the typical drawings and the plans. Installation of pedestrian push-buttons shall include drilling the poles as necessary, mounting the push-button units, mounting the associated regulatory signs and connecting the push-buttons to the control equipment cabinet, installing all pedestrian push-button cable.

17.6.6 School Speed Limit Beacon Assemblies

School speed limit beacon assemblies shall be installed in accordance with the plans. The faces of each assembly shall be covered with a device acceptable to the Engineer until the face is put into operation.

17.6.7 Audible Pedestrian Signals

Audible pedestrian signals shall be installed with all appropriate mounting hardware in accordance with the plans and the following requirements.

17.6.7.1 All miscellaneous hardware and materials necessary for the installation, including 25 mm conduit, shall be installed.

17.6.7.2 The pole or pedestal shall be drilled and tapped as necessary to accommodate conduit.

17.6.7.3 The audible pedestrian signal shall be connected to the control equipment cabinet or to the associated pedestrian signal using signal cable.

17.6.7.4 The audible pedestrian signal shall be set so that the proper signal is presented to the associated crosswalk. Signal NS shall be used for pedestrians using the north/south crosswalks (across the east/west street) and Signal EW shall be used for pedestrians using the east-west crosswalks (across the north/south street).

17.7 CABLE AND WIRE INSTALLATION

Cable and wire shall be installed in accordance with the requirements of the plans, the typical drawings and the following requirements.

17.7.1 General Installation Requirements

The following general requirements apply to all types of wire and cable installation.

17.7.1.1 Wire and Cable Specifications

Wire and cable used on the project shall conform to the requirements of Section 15 of the *Specifications*.

17.7.1.2 No Splices

No splices will be allowed in messenger cable and only aerial, in-line splices will be allowed on all other cables.

17.7.1.3 Mounting Hardware Included

As part of the installation of wires and cables, all necessary mounting hardware shall be installed. This shall include but not be limited to deadend strandvises, shoulder eyebolts, washers, nuts, thimbleyelets, 3-bolt clamps, J-hooks, angle thimbleyes, thimbleyes, split bolt connectors, grounding clamps and lashing material.

17.7.1.4 Multiconductor Splicing

A. Electric Conductors

Electric Wires and Cables shall be spliced and sealed in accordance with standard drawing #'s **Sig-9** and **Sig-10** of these *Specifications.*

B. Fiber Optic Communication Cables

When splicing fiber optic cables, splices shall be made using fusion splicing techniques and fiber optic splice kits. Splices shall conform to the specifications of the cable and splice kit manufacturers. Each splice shall introduce less than 0.5 dB attenuation.

C. Low Voltage Metallic Communication Cables

Metallic communication cables shall be spliced and covered in accordance with *Section 16.4* of these specifications and with the instructions provided with the splice enclosure.

17.7.1.5 Color Coding Maintenance

The color coding of wires and cable conductors shall be maintained through all splices as shown on the chart below.

Straight thru

G	Solid Green
Y	Solid Orange
R	Solid Red
grd	Solid White

Left turn:Protected/Prohibited

G	Green/White
Y	Black/White
R	Red/White
grd	Solid White

Left turn: Protected/Permissive (5 section signal head)

Left Turn Green Arrow: Green/White

Left Turn Amber Arrow: Black/White

G	Solid Green
Y	Solid Orange
R	Solid Red
grd	Solid White

5 Section Right Turn Signal Head

Right Turn Green Arrow: Solid Blue

Right Turn Amber Arrow: Solid Black

G	Solid Green
Y	Solid Orange
R	Solid Red
grd	Solid White

Pedestrian Heads walking WITH the main street (The street designated to flash yellow is considered the main street)

W: Green/Black

DW: Red/Black

Logic Ground: Solid White

Pedestrian Heads walking ACROSS the main street (The street designated to flash yellow is considered the main street)

W: Blue/Black

DW: Orange/Black

Logic Ground: Solid White

Pedestrian Pushbuttons - 18 AWG, 4 wire

PPB for crossing the main street: Black/White

PPB for crossing the side street: Red/Black

17.7.1.6 Protection of Wire and Cable Ends

The raw ends of all wires and cables shall be water- and moisture-proofed and otherwise protected as necessary until they are properly terminated.

17.7.1.7 Minimum Bending Radius

No cable shall be bent, either permanently or temporarily, tighter than the minimum bending radius specified by the cable manufacturer.

17.7.1.8 Slack

Slack shall be provided in all wires and cables in all control equipment cabinets, pull boxes and terminal boxes and at all termination points. At least 600 mm of slack shall be provided in all electric wires and cables. At least 1.2 m of slack shall be provided in all fiber optic cables. All slack wires and cables shall be neatly coiled and wrapped.

17.7.1.9 Maximum Tension

Wires and cables shall be installed in a manner that insures that the wire or cable is not permanently deformed or damaged. Tension gauges shall be used in the pulling operation. The gauges shall automatically release when the tension exceeds 80 percent of the manufacturer's recommended maximum pull tension.

17.7.1.10 No Pulling By Conductors

Cables shall not be pulled by attachment to the conductors, but by attachment to the cable jacket.

17.7.1.11 As-Built Documentation

A diagram or table, labeled by location, shall be furnished for each location where splicing of system cables occurs. It shall show all cables and conductors, including all spares, with their color codes, terminal numbers and functions. Where such splicing occurs at a signalized intersection, the required information for the control equipment cabinet, and all pole terminal compartments may be shown on a single intersection diagram. This information shall be furnished as part of the Documentation and shall conform to all requirements for Documentation as set forth in Article 1.5.

17.7.2 Aerial Cable Installation Requirements

The following requirements apply to the installation of aerial cable.

17.7.2.1 Cable Attachment to Poles

Messenger cable and Figure-8 cable shall be attached to poles using standard cable clamps in mid-run and using deadend strand vises at terminal poles. When messenger cable is used, cable clamps shall be equipped with J-hooks. If Figure 8 cable must be spliced in mid run, it shall be spliced within 1.5m of a pole with an approved splicing mechanism as detailed in Section 17.7.1.4 of these Specifications.

17.7.2.2 Electrical Continuity and Grounding

The electrical continuity of each messenger cable shall be maintained at all splices.

Each messenger cable and the integral support cable of each Figure-8 cable shall be grounded at each end and at intervals of 300 m or less.

17.7.2.3 Installation on Utility Poles

When aerial cable must be installed on a utility pole, all regulations and requirements imposed by the owner of the utility pole shall be complied with. As a minimum, the following requirements shall be complied with.

A. All work shall conform to the requirements of the National Electrical Safety Code (ANSI C2).

B. Cables shall be installed to the same sag as the existing cables immediately above and below them.

C. Where guying and anchoring are required, the guys and anchors shall be installed before the cables are attached to the poles.

D. Attachment to existing guys and anchors shall not be made unless specifically approved by the utility owner in each instance.

E. Guys shall not be bonded to power company grounding electrodes.

F. Cable stringing and attachment operations shall be conducted in a way that will ensure that all proper clearances above the ground and above traveled ways are maintained.

17.7.2.4 Guying

Cable guys shall be installed as shown on the typical drawings or the plans and as directed by the Engineer where it is necessary to balance otherwise unbalanced stresses on poles. The strength of each guy shall be at least equal to the breaking strength of the conductor or cable being guyed. Cable guys shall conform to the following minimum requirements:

A. If a sidewalk or an obviously used pedestrian path is present at the guy location and would be wholly or partially blocked by the guy, a sidewalk guy shall be used. Otherwise, a direct guy shall be used.

B. Guy cables shall be at least 9.52 mm messenger cable as specified in Article 15.4.

17.7.2.5 Drip Loop Required

When installing wires and cables, a drip loop shall be provided, as shown in the typical drawings, in the wire or cable at weatherheads, terminal boxes, signal heads, etc. to prevent water from running along the wire or cable into these devices. The depth of the

drip loop shall be 100 to 150 mm below the entry point.

17.7.2.6 Cable Lashing

The attachment of new cable or wire to existing or new messenger cable or Figure-8 cable shall be accomplished with 1.14 mm (minimum) diameter galvanized steel spiral cable wrap. Lashing shall be accomplished in a manner that results in the wire and cable appearing to be an integral part of the support cable.

17.7.2.7 Hooks and Rings Prohibited

The use of cable rings or hooks for attaching wires and cables to their support cables is prohibited. Where such rings or hooks exist along any span of cable on which new wire or cable must be installed, they shall be removed and both the new and the existing wires and cables shall be lashed as described in paragraph 17.7.2.6.

17.7.2.8 Bending Protection

When installing signal interconnect cable, the cable shall be supported during installation by the use of pulleys or rollers at each pole. The pulleys or rollers at the end points of the pulling section shall have radii at least 25 mm greater than the minimum bending radius of the cable being installed. In no case shall these pulleys or rollers have radii smaller than 75 mm. Pulleys or rollers at intermediate poles may have radii as small as 50 mm.

17.7.2.9 Required Sag

Unless otherwise specified by the Engineer, messenger cable supporting both cable and traffic signal heads shall be allowed a sag in a vertical direction equal to 3 to 4 percent of the length of the span between poles. Messenger cable supporting only wires or cables shall be allowed a vertical sag equal to 3 to 4 percent of the length of the span between poles.

17.7.3 Installation Requirements for Cable in Conduit

The following requirements apply to the installation of wires and cables in conduit.

17.7.3.1 Cable Lubrication

Cables and wires shall be lubricated entering a conduit to prevent damage to the insulation during the installation process. The lubricant shall not cause any physical or chemical degradation of the cable jacket, wire insulation, or conduit.

17.7.3.2 Installation With Existing Circuits

Existing wires and cables in conduits shall be removed, reinstalled and reconnected as necessary to facilitate the installation of new wire and cable. Such existing wires or cables shall not be damaged in any way.

17.7.4 Directly Buried Cable Installation Requirements

Where cable is to be directly buried, the trench shall be at least 900 mm deep and shall not exceed 210 mm in width. Trenching and backfilling shall conform to the requirements of paragraph 17.3.2.

17.7.5 Fiber Optic Cable Termination

When a fiber optic cable conductor (fiber) is to be terminated, a Type ST connector shall be installed on each fiber. The connector shall have an attenuation less than 0.5 dB.

17.8 LOOP SYSTEM INSTALLATION

Loop detector systems for traffic detection shall be installed in accordance with the requirements of the typical drawings, the plans and the following requirements. All loop wire, lead-in cable, loop slot sealant, connectors, saw slots, solder, wire nuts, spade lugs, tape, wire ties, waterproofing and incidental materials required to complete the installation shall be installed. Unless otherwise noted, all conduit and pull boxes shall also be installed.

17.8.1 Saw-Cut Corner Options

Two (2) saw-cut corner options are defined in this article as shown in the typical drawings: Option 1, generally for use in good pavements; and Option 2, generally for use in weak or damaged pavements.

17.8.2 Installation Requirements

17.8.2.1 Each loop system shall be installed in accordance with the requirements of the typical drawings and the plans for each type of loop.

17.8.2.2 Prior to installing the loop wire or lead-in cable, the saw slots shall be cut, the needed conduit shall be installed, and the needed pull boxes shall be installed.

17.8.2.3 Prior to installation of the loop wire, the saw slots shall be cleared of jagged edges or protrusions.

17.8.2.4 The pavement surrounding the saw slot shall be washed and swept clean. The saw slot

shall be cleaned with a high pressure wash method employing an air and water mixture. Following completion of the high pressure wash, slots shall be blown dry with compressed air.

17.8.2.5 The loop wire shall be installed in the slots, taking care not to damage the insulation.

17.8.2.6 Loop wire shall not be spliced at any point. It shall be one (1) continuous piece of wire from the pull box, through the loop, and back to the pull box. The loop wire shall be twisted between the corner of the loop and the pull box a minimum of 15 turns per meter. The loop wires shall be labeled. Labels shall be formed of clear heat-shrinkable tubing installed on each twisted pair of loop wires in the pull box. The legend of each label may either be on a piece of paper slipped between the wires and the tubing before shrinking or be printed on the tubing before shrinking using waterproof drafting ink. The legend shall be legible and shall indicate the associated loop number. The tubing shall be shrunk to form a tight fit on the loop wires near the splice to the lead-in cable. Other methods of labeling may be used if approved by the Engineer.

17.8.2.7 All turns of loop wire required for a loop shall be installed in the same slot.

17.8.2.8 The lead-in cable shall be installed between the control equipment cabinet and the pull box adjacent to the loops. Each lead-in cable shall be one (1) piece between its termini. It shall not be spliced, except on runs in excess of 230 m. All splices shall be made in approved pull boxes or condulets and shall be no closer than 230 m.

17.8.2.9 A single lead-in cable may be used to connect multiple loops as shown on the typical drawings if interconnect cable (lead-in cable Type 3) is specified as the lead-in cable on the plans or in the bid list.

17.8.2.10 Loops to be connected to the same amplifier shall be wired in parallel at the pull box adjacent to the loops unless otherwise specified.

17.8.2.11 A label formed of clear heat-shrinkable tubing shall be installed on each lead-in cable in the control equipment cabinet. The legend of the label may either be on a piece of paper slipped between the cable and the tubing before shrinking or be printed on the tubing before shrinking using waterproof drafting ink. The legend shall be legible and shall indicate the associated loop number and phase identification. The tubing shall be shrunk to form a tight fit on the cable near the end. Other methods of labeling may be used if approved by the Engineer.

17.8.2.12 The loop wire shall be spliced to its associated lead-in cable in the pull box and the splice shall be sealed as shown in the typical drawings.

17.8.2.13 When specified, backer rod may be placed in the slot over the loop wires prior to

placing the sealant.

17.8.2.14 The slots shall be sealed with loop slot sealant in accordance with the typical drawings and the sealant manufacturer's recommendations. Slots shall be dry at the time of sealing. The conduit entrance in the pavement shall be sealed to prevent the flow of loop sealant into the conduit. The viscosity and curing characteristics of the sealant shall be sufficient to allow leveling, but remain flush with the roadway surface when installed on a 10% grade. An open foam material may be used to seal the end of the conduit.

17.9 PAINTING OF NEW CABINETS, POLES, PEDESTALS AND SIGNALS

17.9.1 Painting

Where painting of new control equipment cabinets, signal heads, signal poles and pedestals is required, said painting shall be applied at the factory. No field painting of control equipment cabinets, signal heads, signal poles or pedestals shall be permitted, except when the paint on portions of them has been scratched or marred. In such cases, two (2) field coats of enamel of the same color and grade as the original paint shall be applied to the marred portions.

17.10 ELECTRICAL (POWER) SERVICE

Where required, the electrical service for various traffic control functions shall be installed in accordance with the plans, the typical drawings and the following requirements.

17.10.1 Unless shown on the plans, the exact location of the power source shall be determined in coordination with the City.

17.10.2 The power connection shall be to a single-phase 120/240 volt 3-wire, 60-Hertz supply furnished by the City at a point close to the controller. Only single-phase 120 volts may be brought into the cabinet. Service wire shall be electric service cable with A.W.G. #10 or larger stranded copper wires.

DEFINITIONS

The following words, phrases and operational parameters utilized in these *Specifications* shall have the meanings ascribed to them below. Other technical words, phrases and operations parameters used in these *Specifications* shall have the meanings ascribed to them in the referenced specifications and standards.

AASHTO American Association of State Highway and Transportation Officials.

Acceptable Gap

In gap-reduction controller timing, the current gap value computed by the controller based on the settings of the Passage Time, the Minimum Gap, the Time Before Reduction, and the Time to Reduce parameters.

Actuation A call.

Adjustable Signal

A signal head having the signal faces mounted in the support hardware so that each face may be adjusted, as required, to properly present the indication to approaching traffic.

All-Red Interval

See Red Clearance Interval.

ANSI American National Standards Institute, Incorporated.

Applications Software

Computer programs added to a computer system, in addition to the computer's operating system and basic support programs, that enable the computer to perform the specific tasks (e.g. traffic control, computation, word processing) required by its intended application.

ASCII American Standard Code for Information Interchange.

ASTM American Society of Testing and Materials.

Auxiliary Equipment

Separate devices used to add supplementary features to a controller assembly.

A.W.G. American Wire Gauge.

Back Panel A panel which is mounted on the back of a control equipment cabinet and on which terminals are mounted. For purposes of these *Specifications*, the term back panel may also include the side walls of the cabinet.

Beacon A signal head or heads which is operated only in a flashing mode. The signal head(s) may be a part of a sign assembly.

Beacon Controller Assembly

A controller assembly for controlling the operation of a beacon.

Blank-out Sign

An electrically, internally illuminated sign having a legend which essentially disappears when the internal illumination is off.

Cabinet See Control Equipment Cabinet.

Call A registration of a demand for right-of-way by traffic at a controller unit.

Clearance Interval(s)

The interval(s) occurring between the green right-of-way of one phase and the beginning of a conflicting phase.

Closed-Loop System

A traffic signal system characterized by supervision and monitoring of system operation from a personal type microcomputer via an on-street master, with timing plans and operations schedule data being stored in the local controller but changeable from the microcomputer.

Color Sequence

A description of the displays of all signal faces in each and every interval of a controller's timing sequence.

Communications Unit

An electronic device that receives coded signals from a remote location and translates them into circuit closures to activate other devices and that encodes information and transmits it for remote use.

Conflict Monitor

A device used to continuously check for the presence of conflicting signal indications and to provide an output in response to any detected conflict.

Conformal Coating

A coating applied to printed circuit boards to retard mildew.

Constructed Timing Plan

In a traffic signal system, a timing plan that is assembled by the independent selection of a cycle length from a set of predetermined cycle lengths, a split from a set of predetermined splits, and an offset from a set of predetermined offsets; rather than by the single selection of a unique combination of predetermined, related cycle length, split and offset from a set of such unique combinations.

Control Area

A grouping of generally contiguous traffic signals that are operated in a coordinated relationship. Defined on a timing plan basis.

Control Equipment Cabinet

An outdoor enclosure for housing a controller unit and associated equipment.

Controlled Detector Output

A pulse mode detector output that has a predetermined duration regardless of the length of time a vehicle is in the field of influence of the detector.

Controller (Controller Unit)

That portion of a controller assembly that is devoted to the selection and timing of signal displays.

Controller Assembly

A complete electrical mechanism fully interconnected in a cabinet for controlling the operation of a traffic control device.

Coordinated Operation

The operation of two or more controllers in a predetermined time relationship to achieve progressive movement of traffic.

Coordinator (Coordinating Unit)

A device used to relate the timing of one controller to others.

Cutaway Visor

See Visor.

Cycle In a pretimed controller unit, a complete sequence of signal indications. In an actuated controller unit, a complete cycle is dependent on the presence of calls on all phases.

Cycle Length

The time period in seconds required for one (1) complete cycle.

Date of Installation

The date, according to the Engineer's daily record of construction, that the equipment begins normal continuous operation.

Delayed Output

A detector feature that enables a detector to delay its output for a predetermined length of time after the vehicle enters the detection zone.

Density A measure of the concentration of vehicles, stated as the number of vehicles per mile per lane.

Detection (Vehicle, Pedestrian)

A registration of a demand by vehicles or pedestrians for traffic right-of-way at a controller assembly.

Detector A device for indicating the presence or passage of vehicles or pedestrians.

Detector Amplifier (Detector Unit)

An electronic device that converts the signal generated by an associated sensor or sensors to an output usable by a controller or other device.

Detector Loop

A sensing element of a detector that consists of one (1) or more loops or turns of wire embedded in the pavement to form the inductive portion of a tuned circuit.

Detector Memory

A feature of a controller assembly that retains a detection for future utilization by the assembly. Also simply called Memory. When in operation, it is referred to as Locked Detector Memory. When disabled, it is referred to as Non-Locking Detector Memory.

Detector Mode

A term used to describe the operation of a detector channel output when a presence detection occurs.

1. Pulse Mode - Detector produces a short output pulse when detection occurs.
2. Presence Mode (Continuous Presence Mode) - Detector output continues if any vehicle remains in the field of influence.
3. Limited-Presence Mode - Detector output continues for a limited period of time if any vehicle is in the field of influence.

Digital Controller

A controller which utilizes digital timing.

Digital Timing

A method of timing that operates by counting discrete units.

Disconnect Switch

See Main Power Switch.

Discrete Timing Plan

In a traffic signal system, a timing plan that is a unique combination of predetermined, related cycle length, split and offset selected from a set of such unique combinations; rather than assembled by the independent selection of a cycle length from a set of predetermined cycle lengths, a split from a set of predetermined splits, and an offset from a set of predetermined offsets.

EEPROM Electrically erasable programmable read-only memory.

EIA Electronic Industries Association.

Electrically Alterable Nonvolatile Memory

Random access memory (RAM) which retains its contents in the absence of external power.

Electromechanical Device

An electrical device which is characterized by electrical circuits utilizing relays, step switches, motors or other moving parts.

Engineer The Chief Engineer, Division of Highways, North Carolina Department of Transportation, acting directly or through his duly authorized representatives.

EPROM Erasable programmable read-only memory.

Extend With regard to detectors, the ability of a detector unit to continue its output for a predetermined length of time following an actuation and after the vehicle leaves the detection zone.

Extensible Portion

That portion of the green interval of an actuated phase following the initial portion which may be extended, for example, by traffic actuation.

Extension Limit

The maximum time of the extensible portion for which actuations on a traffic phase may retain the right-of-way after actuation on a conflicting phase.

Fiber Optic Cable

Communications cable that is made up of glass or plastic fiber conductors for the transmission of light rays.

Field Terminals

Devices for connecting conductors entering a cabinet.

First Clearance

The yellow change interval.

Flash Control Switch

A device which, when operated, discontinues normal signal operation and causes the flashing of a predetermined combination of signal indications.

Flasher A device used to open and close signal circuits at a repetitive rate.

Flasher Beacon Controller Assembly

A complete electrical mechanism fully interconnected in a cabinet for controlling the flashing operation of a signal or beacon.

Focal Point

The location relative to the reflector of an optical unit from which light emitted from a source at the location will be redirected by the reflector into a prescribed pattern.

Force Off A command that will force termination of the right-of-way.

Full-Circle Tunnel Visor

A visor which encircles the entire lens. Also called simply full-circle visor. See Visor.

Full-Traffic-Actuated Controller Assembly

A traffic-actuated controller assembly in which means are provided for traffic actuation on all approaches to the intersection.

Gap The time between the end of an actuation of a phase and the beginning of the next actuation of the phase.

Gap Reduction

A feature whereby the unit extension or allowed time spacing between successive vehicle actuations on the phase displaying the green in the extensible portion of the interval is reduced.

Ground Rod A type of grounding electrode.

Grounding Electrode

A metal rod or network that is placed in the ground for the purpose of electrically bonding the earth with electrical equipment to dissipate electrical charges which could damage such equipment or injure personnel.

Hold A command that retains the existing right-of-way.

IMSA International Municipal Signal Association.

Inhibit Maximum Termination

A actuated controller function which, when activated, disables the maximum termination functions of all phases in the associated timing ring.

Initial Interval

See Minimum Green.

Initial Portion

The first timed portion of the green interval in an actuated controller unit.

1. Fixed initial portion - a preset initial portion that does not change.
2. Computed initial portion - an initial portion which is traffic-adjusted.
3. Maximum initial portion - the limit of the computed initial portion.
4. Added initial portion - an increment of time added to the minimum initial portion in response to vehicle actuations.
5. Variable initial - computed initial portion.

Intersection Timing Plan

A unique combination of cycle length, offset and split stored in an intersection controller's or coordinating unit's database.

Interval The part or parts of a signal cycle during which signal indications do not change.

Interval Portion

A discrete subdivision of an interval during which the signals do not change.

Isolated Controller Assembly

A controller assembly which is not part of a coordinated traffic signal system.

ITE Institute of Transportation Engineers.

JEDEC

1. Joint Electronic Device Engineering Council.
2. In programmable logic, a computer file containing information about the programming device in a file format that is a standard approved by the Joint Electronic Device Engineering Council.

Lamp That part of the optical unit of a traffic signal section or an illuminated sign which, when energized, electrically provides the optical unit light source.

Lane See Traffic Lane.

Last Car Passage

A controller feature that assures that, unless terminated by the maximum setting, a force-off command, or other external command, a full passage time will be provided following the last actuation that occurred prior to expiration of the gap in gap-reduction operation.

Legend Word messages or symbols used on signs to convey specific meanings.

Lens That part of the optical unit of a traffic signal section through which light from the light source and reflector passes and, in so doing, is redirected into a prescribed pattern and is filtered to a prescribed color.

Load Switch An electrical device for controlling the connection of the power source for a traffic signal display by means of a low power, low current signal from a controller.

Locking Memory

The mode of controller detector circuit operation in which vehicle actuation during the red or yellow interval of a phase is registered and remembered without the vehicle remaining in the detection zone. See also Detector Memory.

Logic Unit An electrical device for producing one or more electrical switch closures based on a programmed response to one or more electrical inputs.

Loop Detector A detector that senses a change in inductance of its wire loop sensor caused by the passage or presence of a vehicle near the sensor.

Loop System The entire detection element of a loop detection system including the loop wire, the associated loop lead-in cable, and the splice between them.

Magnetic Detector

A detector that senses changes in the earth's magnetic field caused by the movement of a vehicle near its sensor.

Magnetometer Detector

A detector that measures the difference in the level of the earth's magnetic forces caused by the passage or presence of a vehicle near its sensor.

Main Power Switch

A manual switch for disconnecting power to a controller assembly and associated traffic control signals.

Major Street A roadway approach or pair of approaches at an intersection normally carrying the higher traffic volume.

Manual Operation

The operation of a controller assembly by means of a hand-operated device(s). (A push-button is an example of such a device.)

Mast Arm An essentially horizontal, cantilevered structural member of a traffic signal suspension system that supports traffic signal heads over a roadway and is supported by a shaft or mast.

Mast Arm Pole

A vertical structural member of a traffic signal suspension that supports a mast arm.

Master Controller

An electronic device for supervising one or more secondary controller assemblies.

Master Controller Assembly

A controller assembly for supervising a system of secondary controller assemblies.

Master-Secondary Controller Assembly

A controller assembly operating traffic signals and providing supervision of other secondary controller assemblies.

Maximum Green

The maximum length of time that a phase will remain in the green interval after a serviceable call on conflicting a phase.

MCU A single-chip microcomputer unit.

Memory

1. The portion of an electronic device that retains data and operational parameters for use by the unit.
2. Detector memory.

Menu-Driven

A mode of user interface with an electronic device characterized by the making of selections from menus of possible choices displayed on the device.

Microcomputer

A computer utilizing a microprocessor.

Microprocessor

A computer central processing unit wholly contained on a single component or chip.

Minimum Gap

A controller parameter to establish the gap which, when exceeded, will permit the termination of the extensible portion of the associated green interval as if the passage time had expired.

Minimum Green

The first timed portion of a green interval and the shortest time for which that green interval will be displayed.

Minimum Initial Green

See Minimum Green.

Minor Movement Controller Unit

A device that can be added to a controller assembly to provide one (1) or more additional intervals.

Minor Street A roadway approach or approaches at an intersection normally carrying the lesser traffic volume.

Mnemonic Parameters

Abbreviations used in an electronic device to represent the memory allocations for specific parameters.

Modular Design

An equipment structure in which components which perform certain functions are fabricated into plug-in units which can be readily exchanged with similar units.

MUTCD *Manual on Uniform Traffic Control Devices for Streets and Highways* published by the Federal Highway Administration.

National Electric Code

A code governing the installation of electrical equipment and circuits published by the National Fire Prevention Association (NFPA 70).

National Electric Safety Code

A code (ANSI Standard C2) governing the installation of electrical equipment and circuits published by the Institute of Electrical and Electronics Engineers.

NCDOT North Carolina Department of Transportation.

NEC *National Electric Code.*

NEMA National Electrical Manufacturers Association.

NEMA Specifications

When used without qualifying phrases, NEMA Standards Publication No. TS 1, *Traffic Signal Systems*. When used with qualifying phrases, the particular NEMA Standard that is referred to.

NEMA Standard TS-1

NEMA Standards Publication No. TS 1, *Traffic Signal Systems*.

NESC *National Electrical Safety Code*.

Non-Locking Memory

See Detector Memory.

Non-Phase Modular Controller

A controller unit which is designed to contain circuitry for 8 phase operation and which has no field removable modules to provide I/O for intersection operation.

Offset The time relationship, expressed in seconds or percent of cycle length, determined by the difference between a defined point in the coordinated phase green and a system reference point.

On-Street Master

A master controller in a closed-loop system.

Optical Unit An assembly in a traffic signal section consisting of a lens, a reflector, a light source, a light source socket and other components if required, with the necessary supporting parts to be used for providing a single signal indication.

Overlap A right-of-way indication that allows traffic movement when control of the right of way is provided by two (2) or more traffic phases.

PAL Programmable array logic device.

Passage Detection

The ability of a vehicle detector to detect the passage of a vehicle moving through the detection zone and to ignore the presence of a vehicle stopped within the detection zone.

Passage Period

The time allowed for a vehicle to travel at a selected speed from the detector to the nearest point of conflicting traffic.

Passage Time

The controller parameter for setting the passage period. Also called unit extension, vehicle interval and preset gap.

Pedestrian-Actuated Controller Assembly

A controller assembly in which pedestrian intervals can be added to or included in the controller cycle by the actuation of a pedestrian detector.

Pedestrian Clearance Interval

The first clearance interval following the pedestrian WALK indication.

Pedestrian Detector

A detector that is responsive to operation by or the presence of a pedestrian.

Pedestrian Phase

A phase allocated to pedestrian traffic which may provide a pedestrian right-of-way indication either concurrently with one (1) or more vehicular movements or to the exclusion of all vehicular movements.

Pedestrian Push-Button

A pedestrian detector that utilizes a pedestrian operated push-button to place actuations.

Pedestrian Signal

An electrically operated traffic control device composed of one (1) or more indications which is erected for the exclusive purpose of directing pedestrian traffic at a signalized location.

Peripheral Equipment

Equipment related to a computer for performing various ancillary tasks such as printing, data storage and communications.

Phase Modular Controller

A controller unit which is designed to accept field insertable and removable modules to provide I/O for intersection operation. The controller can be configured via this method for 2 phase operation, 4 phase operation, or 8 phase operation. A phase modular controller unit shall not require software changes when reconfigured.

Phase Sequence

A predetermined order in which the phases of a cycle normally occur.

PLD Programmable logic device.

Preemption The transfer of the normal control of signals to a special signal control mode.

Preemption Dwell Phase

A controller phase in which a controller is maintained in the green interval for the duration of preemption following the completion of all necessary emergency clearance intervals.

Preemption Exit Phase

A controller phase during the green interval of which the controller is released from preempted control to normal operation.

Preferred Sequence

The normal order of phase selection within a ring of an actuated controller with calls on all phases.

Presence Detection

The ability of a vehicle detector to sense that a vehicle, whether moving or stopped, has appeared in its field.

Pretimed Controller Assembly

A controller assembly for the operation of traffic signals with predetermined fixed cycle length(s), fixed interval duration(s), and interval sequence(s).

Probe The sensor that is commonly used with a magnetometer-type detector.

PROM Programmable read-only memory device.

PVC Polyvinyl-chloride.

Quick-Connect Block

A terminal block for the termination of communications circuits and conforming to American Telephone and Telegraph Type 66M1.

RAM Random Access Memory device.

Real-time A type of operation in an electronic device in which functions are continuously managed or controlled by an accurate clock (called a real-time clock).

Recall A controller function which, when invoked, causes the automatic return of the right-of-way to the phase associated with the function. There are four (4) modes of recall:

1. Minimum Recall - The controller serves the phase every cycle with at least the minimum green time.
2. Pedestrian Recall - The controller serves the phase every cycle with at least the WALK and pedestrian clearance times.
3. Maximum Recall - The controller serves the phase every cycle with the maximum green time.
4. Soft Recall - The controller serves the phase when all conflicting phases are in a green or red dwell interval and there are no serviceable calls on conflicting phases.

Recall Switch

A manual switch to affect the recall of a controller phase.

Red Clearance Interval

A clearance interval which may follow the yellow change interval during which both the terminating phase and the next right-of-way phase normally display red. Also called all-red and second clearance.

Red Rest A mode of actuated controller operation in which, in the absence of demand on all phases, the controller dwells in a rest interval that displays red in all phases and overlaps and terminates immediately upon receipt of demand on any phase.

Regulatory Sign

A sign used to give notice of traffic laws or regulations.

Rest The interval portion of a phase when all timing requirements have been completed.

ROM Read-only memory device.

Sampling Detector

A vehicle detector used to obtain representative traffic flow information for a traffic signal system or for traffic data collection. Also called system detector.

Second Clearance

See Red Clearance Interval.

Secondary Controller Assembly

A controller assembly which operates traffic signals either independently or under the supervision of a master controller assembly or a central master computer.

Semi-Traffic-Actuated Controller Assembly

A traffic-actuated controller assembly in which means are provided for traffic actuation on one (1) or more but not all approaches to the intersection.

Signal A device which is electrically operated by a controller assembly and which communicates a prescribed action or actions to vehicular or pedestrian traffic.

Signal Face A signal section or combination of signal sections capable of displaying its indication in one (1) direction.

Signal Head An assembly of one (1) or more signal faces.

Signal Indication

1. If referring to a specific signal section, the illumination of the signal lens (or an equivalent device) whereby the movement of vehicular or pedestrian traffic is controlled.
2. If referring to a signal face, set of all illuminated lenses (or equivalent devices) in the signal face.

Signal Installation

All of the equipment and material involved in the control of traffic at one (1) or more intersections by a single controller assembly.

Signal Section

An optical unit and housing capable of displaying one (1) indication.

Signal Sequence

The order of intervals and their corresponding signal indications during a cycle.

Signal Shutdown Switch

A manual switch to discontinue the operation of traffic control signals without affecting the power supply to other components in the controller cabinet.

Skipability The ability of an actuated controller to skip or not serve phases on which there is no demand.

Soft Recall

See Recall.

Software The computer programs used by a computer or other electronic device to perform logical functions that govern how the device functions.

Solid-State Device

A device which is characterized by electrical circuits, the active components of which are semi-conductors, to the exclusion of electromechanical devices or electron tubes.

Span Wire A steel cable, supported by poles, from which signal heads are suspended.

Specifications

1. When capitalized initially and without qualifying terms, these North Carolina Department of Transportation *Traffic Signal Specifications*.
2. When capitalized initially with qualifying terms, the specific specification document referred to.
3. When not capitalized, all of the written requirements for the associated project.

Split A division of the cycle length to each of the various phases.

Standard Dimension Ratio

The ratio of pipe or conduit outside diameter to wall thickness.

Standard Specifications

Standard Specifications for Roads and Structures published by the North Carolina Department of Transportation.

Stop-Timing A controller input which, when activated, causes cessation of controller unit ring timing for the duration of such activation.

Strain Pole A pole, used to support a span wire traffic signal suspension, which has sufficient strength and stiffness to resolve all horizontal stress within itself without the use of guys.

Stretch See Extend.

Subsystem

1. From an operations perspective, a Control Area.
2. From an electrical perspective, a grouping of signalized intersections that are connected together for the purpose of providing coordinated operation.

Surge Protector

A device for protecting electronic equipment from damage due to lightning and excessive voltage conditions.

System Detector

See Sampling Detector.

Time-Based Coordinated Operation

Coordinated operation of two (2) or more controllers without the need for interconnecting them.

Time-Based Coordinator

A coordinating unit that uses a real-time clock to maintain time-based coordinated operation of a traffic signal controller.

Time Before Reduction

A controller parameter that permits setting of the time which must expire from the occurrence of the phase green with a serviceable conflicting call to the beginning of the reduction in the acceptable gap from the passage time to the minimum gap.

Time Switch

A real-time device programmable for the selection of events according to a predetermined time schedule.

Time to Reduce

A controller parameter that permits setting of the amount of time required for the acceptable gap to be reduced from the passage time to the minimum gap once reduction begins.

Timed Overlap

An overlap which does not terminate concurrently with one (1) or more of its associated phases, but displays at least a lagging green interval, yellow change interval, and red clearance interval. The timing of the lagging intervals shall begin with the beginning of the phase yellow change interval. No phase shall time during the display of the lagging intervals.

Timing Function

1. A specific controller parameter that is adjustable to control the timing of a related interval or function.
2. Sometimes, all of the controller parameters for a phase as defined in NEMA Standards Publication No. TS-1.

Timing Plan

When referring to an intersection, an Intersection Timing Plan. When referring to a control area, the intersection timing plans for all intersections in the control area that

are intended to be in effect simultaneously. See also Constructed Timing Plan and Discrete Timing Plan.

Track Clearance Phase

A controller phase to which a controller is forced upon initiation of a railroad preemption **for the purpose of clearing traffic which may be stopped on the railroad tracks.**

Traffic Pedestrians, vehicles, and other conveyances using any street for purposes of travel.

Traffic-Actuated Controller Assembly

A controller assembly for the operation of traffic control devices in accordance with varying traffic demand registered with the controller by detectors.

Traffic Control Device

Any traffic sign, traffic signal, traffic marking, or other device erected or placed over, on, or adjacent to a roadway by authority of a public agency having jurisdiction for regulating, warning, or guiding traffic.

Traffic Lane A width of roadway intended to accommodate the forward movement of a single line of vehicles.

Traffic Phase

Those right-of-way, change and clearance intervals in a cycle assigned to any independent movement(s) of traffic.

Traffic-Responsive Operation

A mode of signal system operation in which traffic data from sampling detectors is continuously updated and analyzed to automatically select the signal system's operational parameters from predetermined sets of parameters.

Traffic Right-of-Way

The right of a vehicle or pedestrian to proceed in a lawful manner before another vehicle or pedestrian crossing under such circumstances as to present danger of collision without granting precedence to the other.

Traffic Sign A device mounted on a fixed or portable support for the purpose of regulating, warning, or guiding traffic by a specific message conveyed by words or symbols.

Tunnel Visor See Visor.

Unit Extension

Passage Time.

Variable Initial

See Initial Portion.

Vehicle Every licensable device in, upon, or by which any person or property is or may be transported or drawn upon a street, except devices moved by human power.

Vehicle Clearance Interval

See Yellow Change Interval.

Vehicle Detector Unit

See Detector Amplifier.

Vehicular Phase

A controller phase allocated to vehicular traffic.

Visor A hood on a signal section which encompasses all or a portion of the lens and shields the lens face from direct ambient light. Visors are of three types as follows.

1. Cutaway Visor - A visor which has its lower half partially removed and contoured and which encircles approximately 300 degrees of the lens.
2. Tunnel Visor - A visor which encircles the entire lens except a segment of the circumference at the bottom of the lens equal to approximately 100 mm for 200 mm signal sections and 150 mm for 300 mm signal sections.
3. Full Circle Tunnel Visor - A visor which encircles the entire lens.

Waveform, (A x B)

With regard to surge protection, a test pulse pattern having timing A x B as defined for current waveforms in ANSI/IEEE Std. 4-1978.

Yellow Change Interval

The first interval following the green right-of-way interval in which the signal indication(s) for that phase is yellow. Also referred to as first clearance interval or vehicle clearance interval.

Yield In a coordinating unit or communications unit, a command which permits an associated actuated controller transfer of the right-of-way to one or more conflicting phases while in an interconnected system. In a controller, a command which permits transfer of the right-of-way (the inverse of Hold).

APPENDIX A
ENGLISH SUBSTITUTIONS

This appendix to the *Specifications* defines English substitutions for metric measures for standard sizes of conduit, traffic signs, and spanwire hardware as required by these *Specifications*.

A.1 STANDARD CONDUIT AND PIPE SIZES

Conduit specified by metric sizing shall use standard trade size conduit as required by Table A.1.

Nominal Size	
Metric (mm)	English (Inch)
15	1/2
16	5/8
20	3/4
25	1
32	1 1/4
40	1 1/2
50	2
65	2 1/2
80	3
90	3 1/2
100	4
115	4 1/2
125	5
150	6

Table A.1

A.2 TRAFFIC SIGNS

Standard English sized signs may be substituted for metric specified sizes as allowed by the schedule of Table A.2.

Metric (mm)	English (Inch)
230 x 300	9 x 12
300 x 690	12 x 27
600 x 750	24 x 30
600 x 900	24 x 36
750 x 900	30 x 36

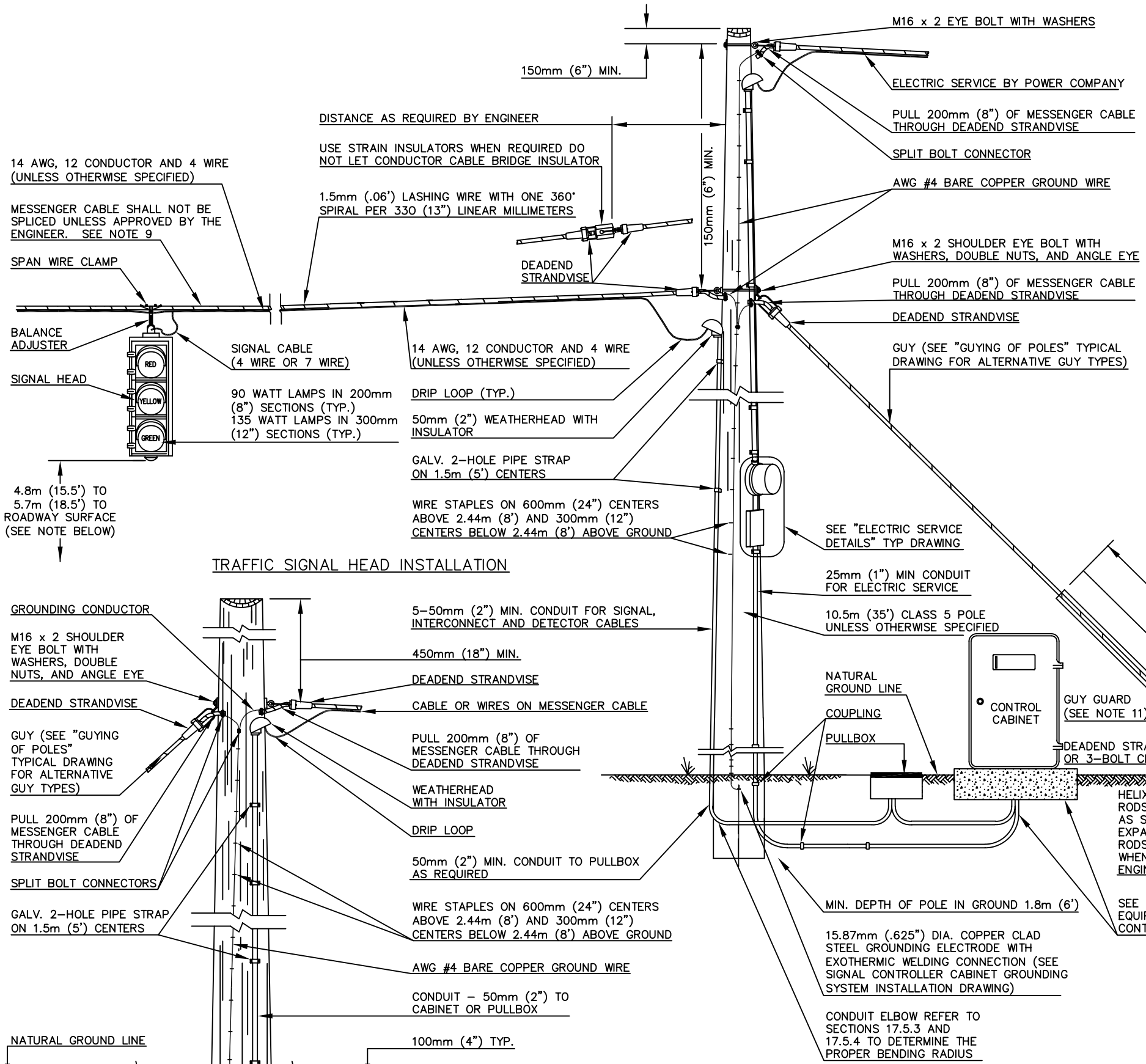
Table A.2

A.3 SPANWIRE HARDWARE

The contractor may substitute 5/8 inch coarse thread hardware for use on the spanwire and guy assemblies for the M16 x 2 hardware required by these *Specifications*. The contractor shall use 5/8 inch coarse thread hardware where required for campatibility with existing installations

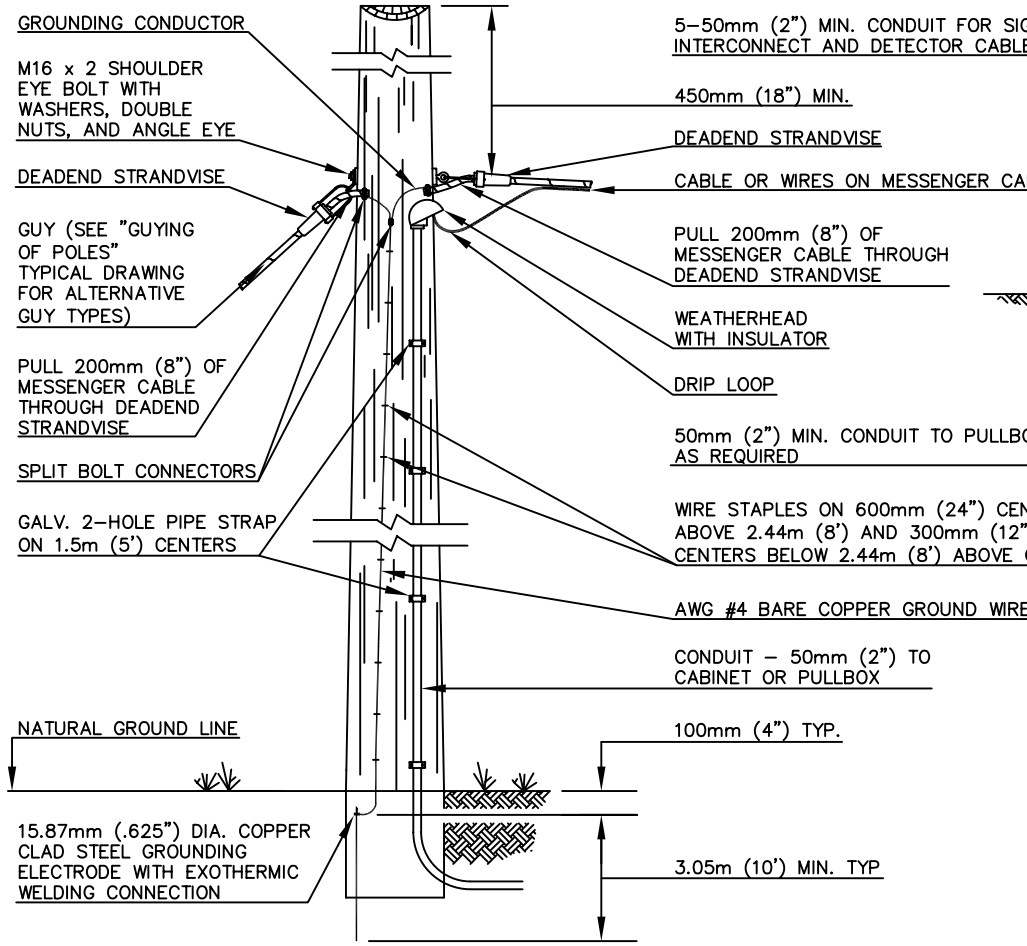
NOTES:

1. POWER SUPPLY AT CONTROLLER TERMINALS TO BE 120 VOLTS SINGLE–PHASE 60 HERTZ.
2. ALL SPAN WIRE HARDWARE TO BE HOT DIP GALVANIZED PER ASTM A153, EXCEPT STRANDVISES AND STRAND LINKS SHALL BE ALUMINUM.
3. ALL SUBSTITUTIONS FOR PARTS CALLED FOR ON PLANS MUST BE PRE–APPROVED BY THE CITY.
4. ANCHOR RODS SHALL BE 15.8mm (.625") MINIMUM DIAMETER FOR LENGTHS UP TO 2.4m (8') INCLUSIVE AND 19mm (.75") MINIMUM DIAMETER FOR LENGTHS OVER 2.4m (8').
5. INTERCONNECT CABLE SPAN SHALL BE GROUNDED AT EACH CONTROLLER LOCATION OR AS DIRECTED BY THE ENGINEER. (MAXIMUM OF 300m BETWEEN POINTS OF GROUNDING).
6. ALL WORK AND MATERIALS SHALL CONFORM TO THE NATIONAL ELECTRIC CODE, TO THE NATIONAL ELECTRIC SAFETY CODE, AND TO THE TRAFFIC SIGNAL SPECIFICATIONS.
7. ALL GROUNDING ELECTRODES TO BE 15.87mm (.625") DIAMETER COPPER CLAD STEEL RODS WITH A MINIMUM LENGTH OF 3.05m (10'). RODS WILL BE DRIVEN INTO UNDISTURBED EARTH.
8. SPLICES IN SIGNAL CABLE SHALL BE MAD ONLY AT SIGNAL HEADS AND OTHER ELECTRICAL EQUIPMENT UNLESS APPROVED BY THE ENGINEER.
9. SAG OF SPAN WIRE SHALL BE 2 TO 40 PERCENT OF SPAN LENGTH.
10. PREFERRED MINIMUM HEIGHT OF SIGNAL HEADS ABOVE ROADWAY SURFACE IS 5.1m (16.5').
11. EACH DOWN GUY SHALL BE EQUIPPED WITH A 2.4m (8') ULTRA VIOLET STABILIZED HIGH IMPACT BRIGHT YELLOW 38mm (1.5") HIGH DENSITY POLYETHYLENE FULL ROUND GUY GUARD.
12. ALL EYE HARDWARE (EYE BOLTS, EYE NUTS, ANGLE EYES, EYE BOLT ANCHOR RODS) SHALL HAVE ROUNDED GROOVES IN THE EYES TO PROTECT THE MESSENGER CABLE OR GUY CABLES FROM SHARP BENDING AND KINKING A SEPARATE GROOVE SHALL BE PROVIDED FOR EACH CABLE TO BE TERMINATED,
13. ALL DIMENSIONS ARE MILLIMETERS "mm". ENGLISH MEASUREMENTS ARE ALSO SHOWN (").

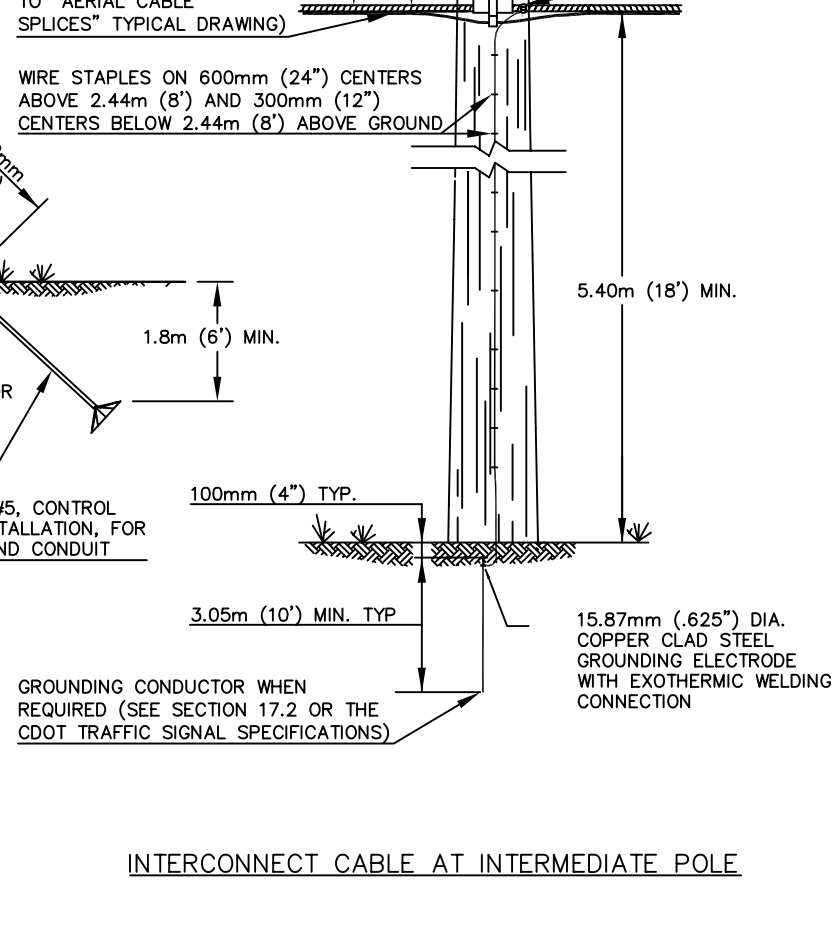

150mm (6") MIN.
DISTANCE AS REQUIRED BY ENGINEER
USE STRAIN INSULATORS WHEN REQUIRED DO NOT LET CONDUCTOR CABLE BRIDGE INSULATOR
14 AWG, 12 CONDUCTOR AND 4 WIRE (UNLESS OTHERWISE SPECIFIED)
1.5mm (.06') LASHING WIRE WITH ONE 360° SPIRAL PER 330 (13") LINEAR MILLIMETERS
MESSENGER CABLE SHALL NOT BE SPLICED UNLESS APPROVED BY THE ENGINEER. SEE NOTE 9
SPAN WIRE CLAMP
DEADEND STRANDVISE
150mm (6") MIN.
BALANCE ADJUSTER
SIGNAL CABLE (4 WIRE OR 7 WIRE)
14 AWG, 12 CONDUCTOR AND 4 WIRE (UNLESS OTHERWISE SPECIFIED)
SIGNAL HEAD
RED
YELLOW
GREEN
90 WATT LAMPS IN 200mm (8") SECTIONS (TYP.)
135 WATT LAMPS IN 300mm (12") SECTIONS (TYP.)
DRIP LOOP (TYP.)
50mm (2") WEATHERHEAD WITH INSULATOR
GALV. 2–HOLE PIPE STRAP ON 1.5m (5') CENTERS
4.8m (15.5') TO 5.7m (18.5') TO ROADWAY SURFACE (SEE NOTE BELOW)
WIRE STAPLES ON 600mm (24") CENTERS ABOVE 2.44m (8') AND 300mm (12") CENTERS BELOW 2.44m (8') ABOVE GROUND
M16 x 2 EYE BOLT WITH WASHERS
ELECTRIC SERVICE BY POWER COMPANY
PULL 200mm (8") OF MESSENGER CABLE THROUGH DEADEND STRANDVISE
SPLIT BOLT CONNECTOR
AWG #4 BARE COPPER GROUND WIRE
M16 x 2 SHOULDER EYE BOLT WITH WASHERS, DOUBLE NUTS, AND ANGLE EYE
PULL 200mm (8") OF MESSENGER CABLE THROUGH DEADEND STRANDVISE
DEADEND STRANDVISE
GUY (SEE "GUYING OF POLES" TYPICAL DRAWING FOR ALTERNATIVE GUY TYPES)
SEE "ELECTRIC SERVICE DETAILS" TYP DRAWING
25mm (1") MIN CONDUIT FOR ELECTRIC SERVICE
10.5m (35') CLASS 5 POLE UNLESS OTHERWISE SPECIFIED
NATURAL GROUND LINE
COUPLING
PULLBOX
CONTROL CABINET
GUY GUARD (SEE NOTE 11)
DEADEND STRANDVISE OR 3–BOLT CLAMP
2.4m (8')
600mm (24")
150mm (6")
1.8m (6') MIN.
HELIX TYPE ANCHOR RODS SHOULD BE USED AS STANDARD. EXPANDING TYPE ANCHOR RODS SHOULD BE USED WHEN REQUIRED BY THE ENGINEER
MIN. DEPTH OF POLE IN GROUND 1.8m (6')
SEE STANDARD DETAIL #5, CONTROL EQUIPMENT CABINET INSTALLATION, FOR CONTROLLER CABINET AND CONDUIT
15.87mm (.625") DIA. COPPER CLAD STEEL GROUNDING ELECTRODE WITH EXOTHERMIC WELDING CONNECTION (SEE SIGNAL CONTROLLER CABINET GROUNDING SYSTEM INSTALLATION DRAWING)
CONDUIT ELBOW REFER TO SECTIONS 17.5.3 AND 17.5.4 TO DETERMINE THE PROPER BENDING RADIUS

TRAFFIC SIGNAL HEAD INSTALLATION

INSTALLATION OF POLE AND GROUND MOUNT CONTROLLER INSTALLATION


GROUNDING CONDUCTOR
M16 x 2 SHOULDER EYE BOLT WITH WASHERS, DOUBLE NUTS, AND ANGLE EYE
DEADEND STRANDVISE
GUY (SEE "GUYING OF POLES" TYPICAL DRAWING FOR ALTERNATIVE GUY TYPES)
PULL 200mm (8") OF MESSENGER CABLE THROUGH DEADEND STRANDVISE
SPLIT BOLT CONNECTORS
GALV. 2–HOLE PIPE STRAP ON 1.5m (5') CENTERS
5–50mm (2") MIN. CONDUIT FOR SIGNAL, INTERCONNECT AND DETECTOR CABLES
450mm (18") MIN.
DEADEND STRANDVISE
CABLE OR WIRES ON MESSENGER CABLE
PULL 200mm (8") OF MESSENGER CABLE THROUGH DEADEND STRANDVISE
WEATHERHEAD WITH INSULATOR
DRIP LOOP
50mm (2") MIN. CONDUIT TO PULLBOX AS REQUIRED
WIRE STAPLES ON 600mm (24") CENTERS ABOVE 2.44m (8') AND 300mm (12") CENTERS BELOW 2.44m (8') ABOVE GROUND
AWG #4 BARE COPPER GROUND WIRE
CONDUIT – 50mm (2") TO CABINET OR PULLBOX
NATURAL GROUND LINE
100mm (4") TYP.
15.87mm (.625") DIA. COPPER CLAD STEEL GROUNDING ELECTRODE WITH EXOTHERMIC WELDING CONNECTION
3.05m (10') MIN. TYP

AERIAL – TO – UNDERGROUND CABLE TRANSITION


1.5mm (.06') LASHING WIRE WITH ONE 360° SPIRAL PER 330 (13") LINEAR MILLIMETERS
INTERCONNECT CABLE ON 6.35mm (.25") MIN. MESSENGER CABLE OR FIGURE 8 INTERCONNECT CABLE
INTERCONNECT CABLE (ALL SPLICES SHALL CONFORM TO "AERIAL CABLE SPLICES" TYPICAL DRAWING)
WIRE STAPLES ON 600mm (24") CENTERS ABOVE 2.44m (8') AND 300mm (12") CENTERS BELOW 2.44m (8') ABOVE GROUND
10.5m CLASS 5 POLE UNLESS SPECIFIED OTHERWISE
3 BOLT CLAMP WITH "J" HOOK
SPLIT BOLT CONNECTOR
5.40m (18') MIN.
100mm (4") TYP.
3.05m (10') MIN. TYP
15.87mm (.625") DIA. COPPER CLAD STEEL GROUNDING ELECTRODE WITH EXOTHERMIC WELDING CONNECTION
GROUNDING CONDUCTOR WHEN REQUIRED (SEE SECTION 17.2 OR THE CDOT TRAFFIC SIGNAL SPECIFICATIONS)

INTERCONNECT CABLE AT INTERMEDIATE POLE

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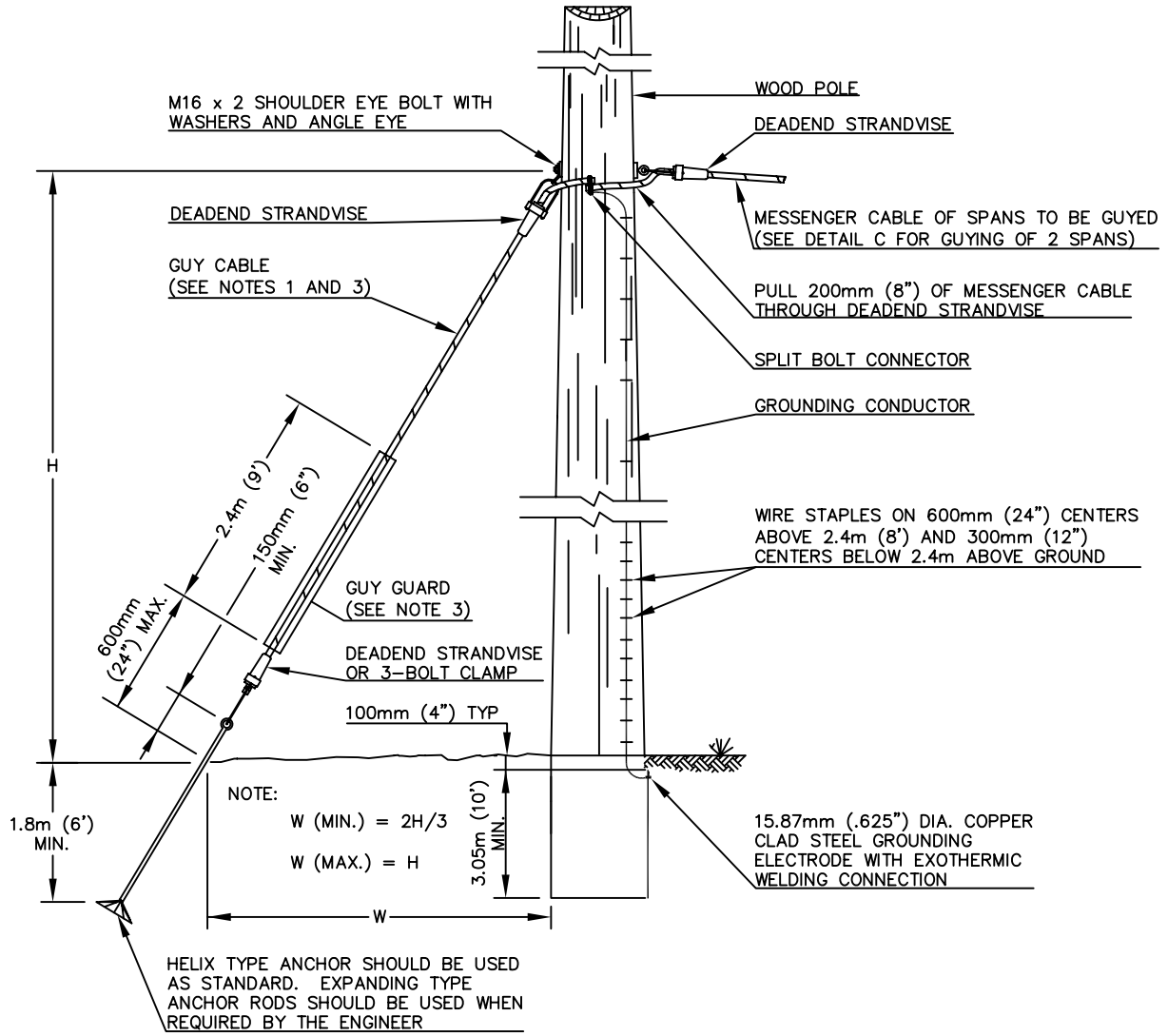
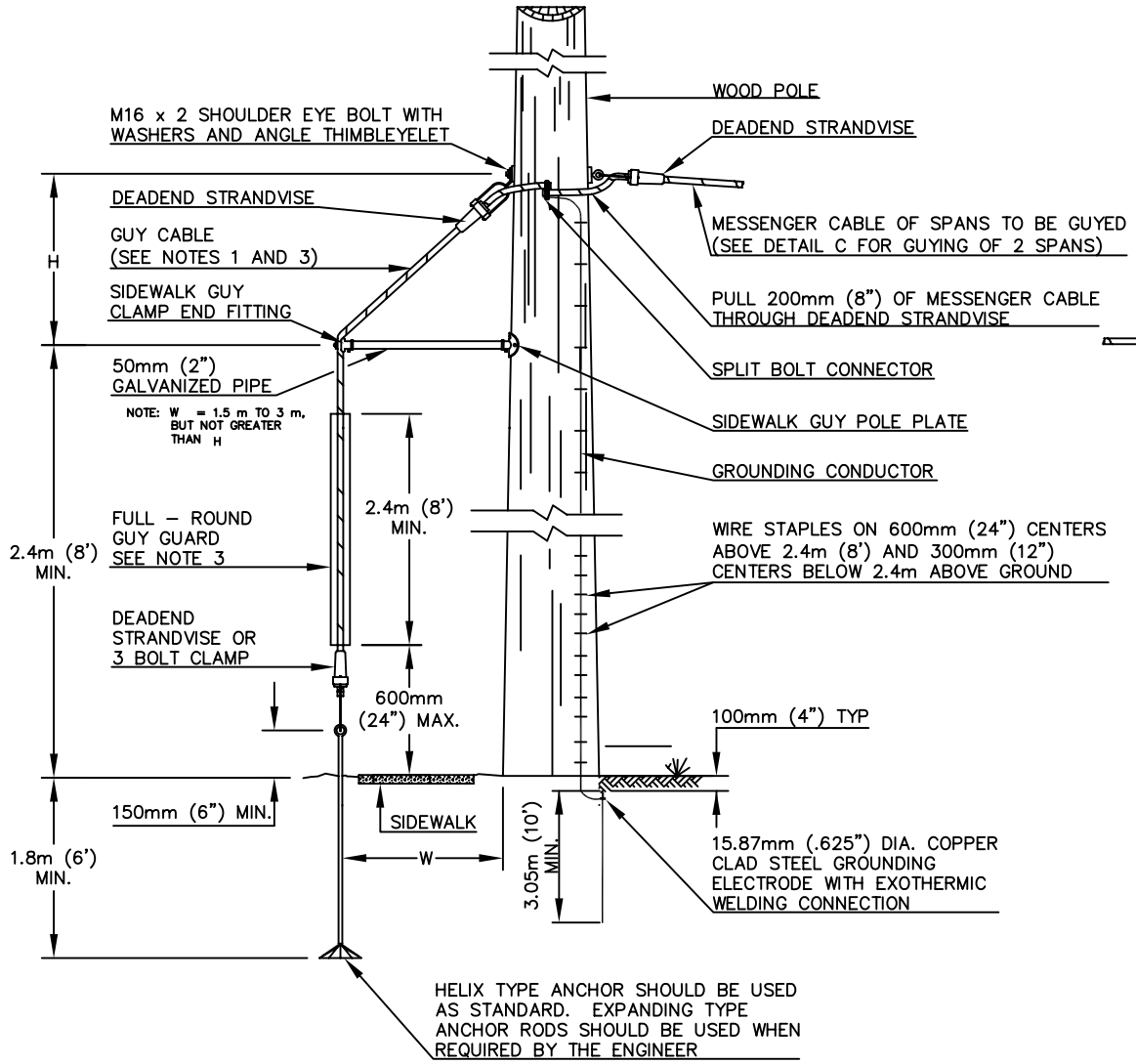
STANDARD DRAWING FOR
SPAN WIRE SIGNAL INSTALLATION
VARIOUS INSTALLATIONS AT
WOOD POLES

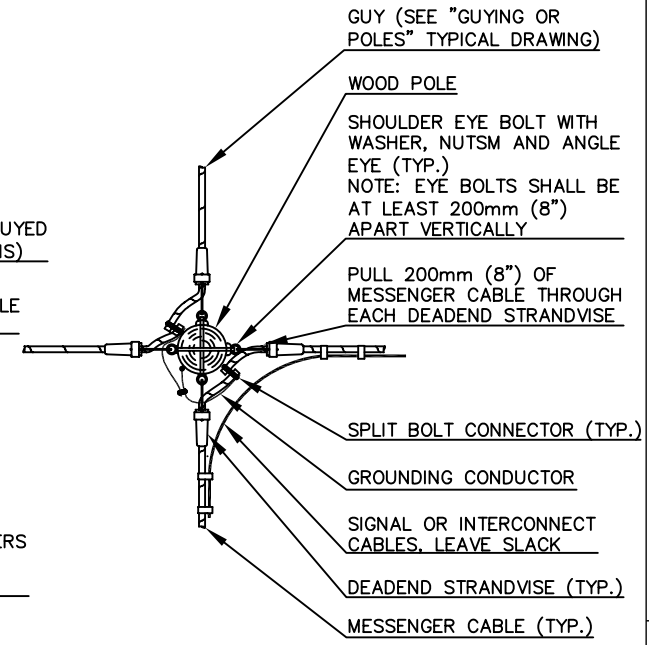
SHEET NO.
SIG–1


M16 x 2 SHOULDER EYE BOLT WITH WASHERS AND ANGLE EYE
WOOD POLE
DEADEND STRANDVISE
DEADEND STRANDVISE
MESSENGER CABLE OF SPANS TO BE GUYED (SEE DETAIL C FOR GUYING OF 2 SPANS)
GUY CABLE (SEE NOTES 1 AND 3)
PULL 200mm (8") OF MESSENGER CABLE THROUGH DEADEND STRANDVISE
SPLIT BOLT CONNECTOR
GROUNDING CONDUCTOR
H
2.4m (9')
150mm (6") MIN.
600mm (24") MAX.
WIRE STAPLES ON 600mm (24") CENTERS ABOVE 2.4m (8') AND 300mm (12") CENTERS BELOW 2.4m ABOVE GROUND
GUY GUARD (SEE NOTE 3)
DEADEND STRANDVISE OR 3-BOLT CLAMP
100mm (4") TYP
NOTE:
W (MIN.) = 2H/3
W (MAX.) = H
1.8m (6') MIN.
3.05m (10') MIN.
W
15.87mm (.625") DIA. COPPER CLAD STEEL GROUNDING ELECTRODE WITH EXOTHERMIC WELDING CONNECTION
HELIX TYPE ANCHOR SHOULD BE USED AS STANDARD. EXPANDING TYPE ANCHOR RODS SHOULD BE USED WHEN REQUIRED BY THE ENGINEER

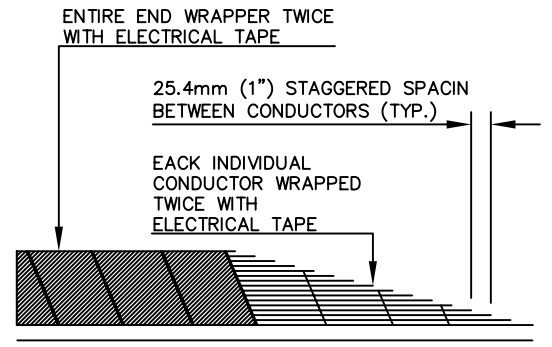
DETAIL A DIRECT DOWN GUY


M16 x 2 SHOULDER EYE BOLT WITH WASHERS AND ANGLE THIMBLEYELET
WOOD POLE
DEADEND STRANDVISE
DEADEND STRANDVISE
MESSENGER CABLE OF SPANS TO BE GUYED (SEE DETAIL C FOR GUYING OF 2 SPANS)
GUY CABLE (SEE NOTES 1 AND 3)
PULL 200mm (8") OF MESSENGER CABLE THROUGH DEADEND STRANDVISE
SIDEWALK GUY CLAMP END FITTING
SPLIT BOLT CONNECTOR
50mm (2") GALVANIZED PIPE
NOTE: W = 1.5 m TO 3 m, BUT NOT GREATER THAN H
SIDEWALK GUY POLE PLATE
H
2.4m (8') MIN.
GROUNDING CONDUCTOR
FULL - ROUND GUY GUARD SEE NOTE 3
WIRE STAPLES ON 600mm (24") CENTERS ABOVE 2.4m (8') AND 300mm (12") CENTERS BELOW 2.4m ABOVE GROUND
2.4m (8') MIN.
DEADEND STRANDVISE OR 3 BOLT CLAMP
600mm (24") MAX.
100mm (4") TYP
150mm (6") MIN.
SIDEWALK
W
1.8m (6') MIN.
3.05m (10') MIN.
15.87mm (.625") DIA. COPPER CLAD STEEL GROUNDING ELECTRODE WITH EXOTHERMIC WELDING CONNECTION
HELIX TYPE ANCHOR SHOULD BE USED AS STANDARD. EXPANDING TYPE ANCHOR RODS SHOULD BE USED WHEN REQUIRED BY THE ENGINEER

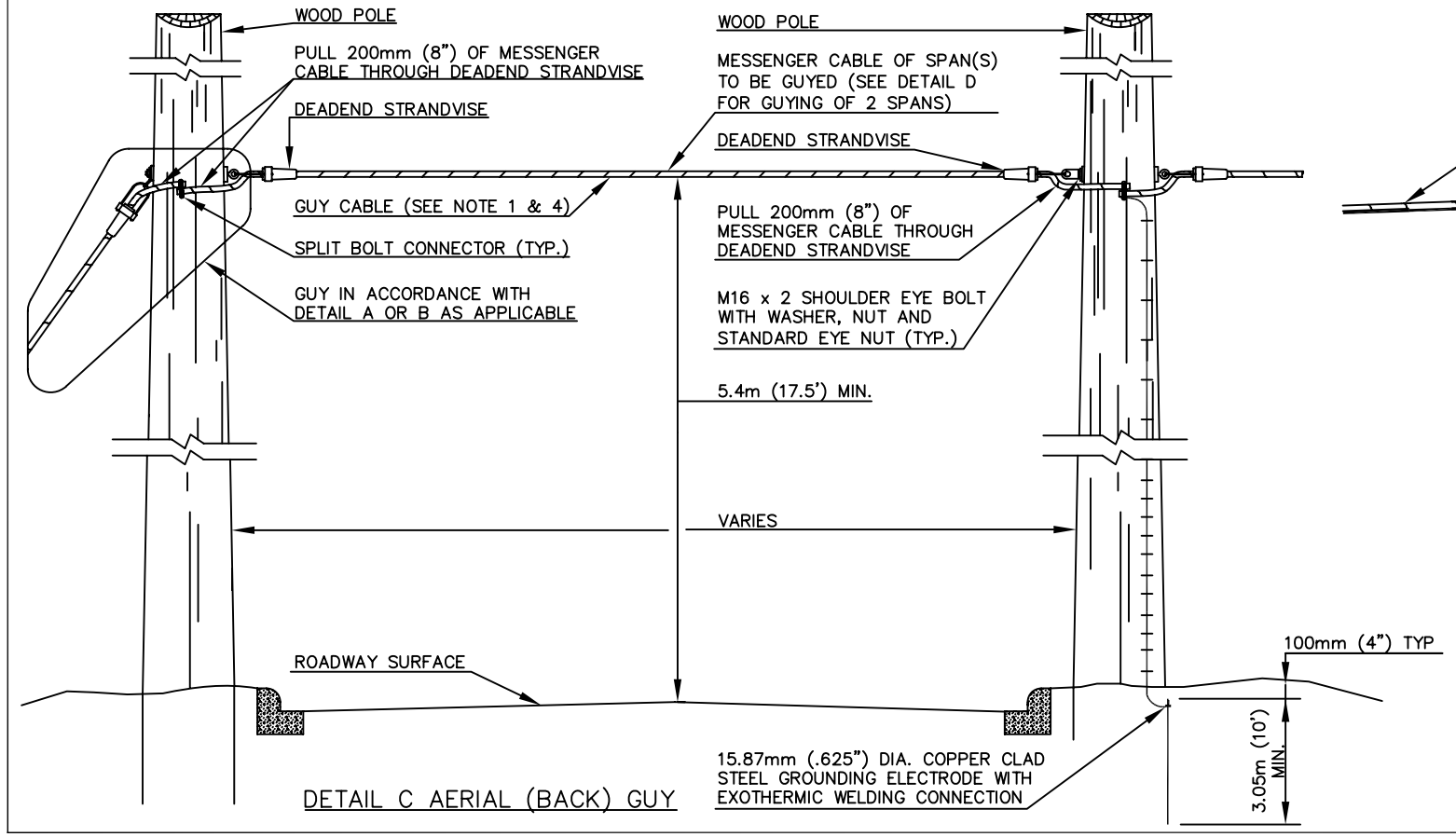
DETAIL D SIDEWALK DOWN GUY


GUY (SEE "GUYING OR POLES" TYPICAL DRAWING)
WOOD POLE
SHOULDER EYE BOLT WITH WASHER, NUTSM AND ANGLE EYE (TYP.)
NOTE: EYE BOLTS SHALL BE AT LEAST 200mm (8") APART VERTICALLY
PULL 200mm (8") OF MESSENGER CABLE THROUGH EACH DEADEND STRANDVISE
SPLIT BOLT CONNECTOR (TYP.)
GROUNDING CONDUCTOR
SIGNAL OR INTERCONNECT CABLES, LEAVE SLACK
DEADEND STRANDVISE (TYP.)
MESSENGER CABLE (TYP.)

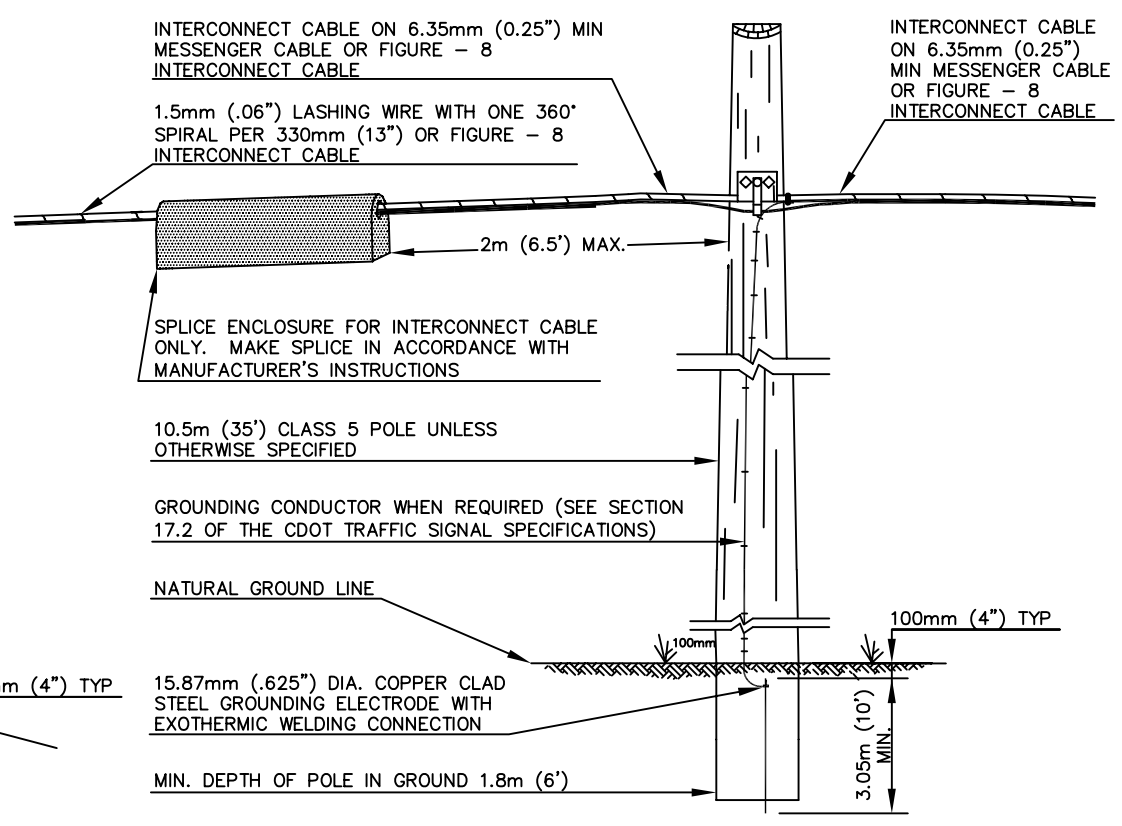
DETAIL B TREATMENT OF MULTIPLE SPANS AT WOOD POLE (PLAN VIEW)


ENTIRE END WRAPPER TWICE WITH ELECTRICAL TAPE
25.4mm (1") STAGGERED SPACIN BETWEEN CONDUCTORS (TYP.)
EACK INDIVIDUAL CONDUCTOR WRAPPED TWICE WITH ELECTRICAL TAPE

DETAIL F TERMINATION OF SIGNAL CABLE


WOOD POLE
PULL 200mm (8") OF MESSENGER CABLE THROUGH DEADEND STRANDVISE
DEADEND STRANDVISE
WOOD POLE
MESSENGER CABLE OF SPAN(S) TO BE GUYED (SEE DETAIL D FOR GUYING OF 2 SPANS)
DEADEND STRANDVISE
GUY CABLE (SEE NOTE 1 & 4)
SPLIT BOLT CONNECTOR (TYP.)
GUY IN ACCORDANCE WITH DETAIL A OR B AS APPLICABLE
PULL 200mm (8") OF MESSENGER CABLE THROUGH DEADEND STRANDVISE
M16 x 2 SHOULDER EYE BOLT WITH WASHER, NUT AND STANDARD EYE NUT (TYP.)
5.4m (17.5') MIN.
VARIES
ROADWAY SURFACE
100mm (4") TYP
3.05m (10') MIN.
15.87mm (.625") DIA. COPPER CLAD STEEL GROUNDING ELECTRODE WITH EXOTHERMIC WELDING CONNECTION

DETAIL C AERIAL (BACK) GUY


INTERCONNECT CABLE ON 6.35mm (0.25") MIN MESSENGER CABLE OR FIGURE - 8 INTERCONNECT CABLE
INTERCONNECT CABLE ON 6.35mm (0.25") MIN MESSENGER CABLE OR FIGURE - 8 INTERCONNECT CABLE
1.5mm (.06") LASHING WIRE WITH ONE 360° SPIRAL PER 330mm (13") OR FIGURE - 8 INTERCONNECT CABLE
2m (6.5') MAX.
SPLICE ENCLOSURE FOR INTERCONNECT CABLE ONLY. MAKE SPLICE IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS
10.5m (35') CLASS 5 POLE UNLESS OTHERWISE SPECIFIED
GROUNDING CONDUCTOR WHEN REQUIRED (SEE SECTION 17.2 OF THE CDOT TRAFFIC SIGNAL SPECIFICATIONS)
NATURAL GROUND LINE
100mm
100mm (4") TYP
15.87mm (.625") DIA. COPPER CLAD STEEL GROUNDING ELECTRODE WITH EXOTHERMIC WELDING CONNECTION
3.05m (10') MIN.
MIN. DEPTH OF POLE IN GROUND 1.8m (6')

DETAIL E INTERCONNECT CABLE SPLICE DETAIL

NOTES:

1. GUY CABLE SHALL BE MESSENGER CABLE OF THE SAME SIZE AS THE LARGER MESSENGER CABLE OF THE SPANS TO BE GUYED.
2. ALL GROUNDING SHALL CONFORM TO NATIONAL ELECTRIC CODE AND TO "VARIOUS INSTALLATIONS AT WOOD POLES" TYPICAL DRAWING.
3. EACH DOWN GUY SHALL BE QUIPPED WITH AN 2.4m (8'), ULTRA VIOLET STABILIZED, HIGH IMPACT, BRIGHT YELLOW, 38mm (1.5") HIGH DENSITY POLYETHYLENE FULL ROUND GUY GUARD.
4. EACH SPAN SHALL BE GUYED SEPARATELY.
5. ALL EYE HARDWARE (EYE BOLTS, EYE NUTS, ANGLE EYES, EYES, EYS BOLT ANCHOR RODS) SHALL HAVE ROUNDED GROOVES IN THEEYES TO PROTECT THE MESSENGER CABLES FROM SHARP BENDING AND KINKING. A SEPERATE GROOVE SHALL BE PROVIDED FOR EACH CABLE TO BE TERMINATED.
6. ALL HOLES DRILLED INTO POLES SHALL BE SEPARATED BY A MINIMUM VERTICAL DISTANCE OF 150mm (6").

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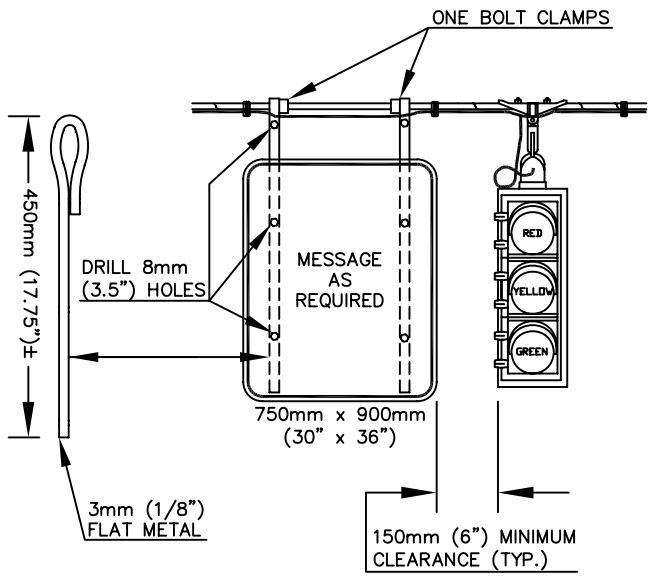
STANDARD DRAWING FOR AERIAL CABLE SPLICES GUYING OF POLES

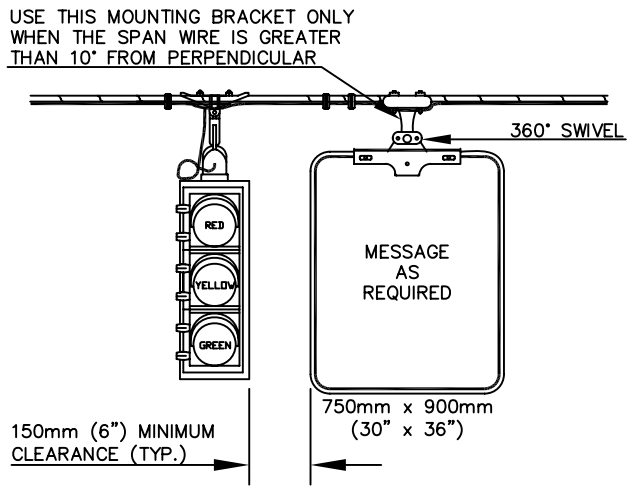
SHEET NO.
SIG-2

OVERHEAD SIGNAL AND SIGN INSTALLATION

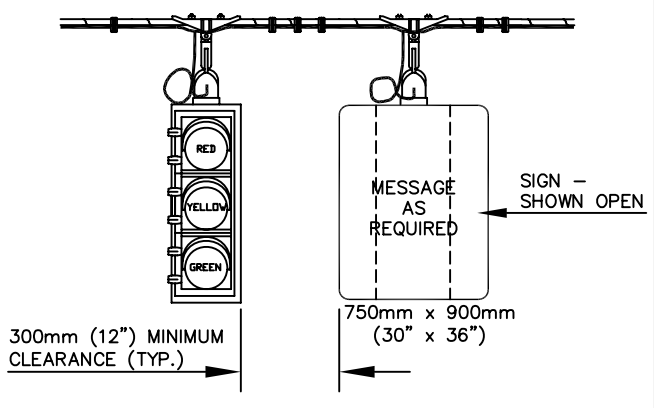
SPAN WIRE MOUNTED SIGNALS & SIGNS



TYPE I SIGN MOUNT

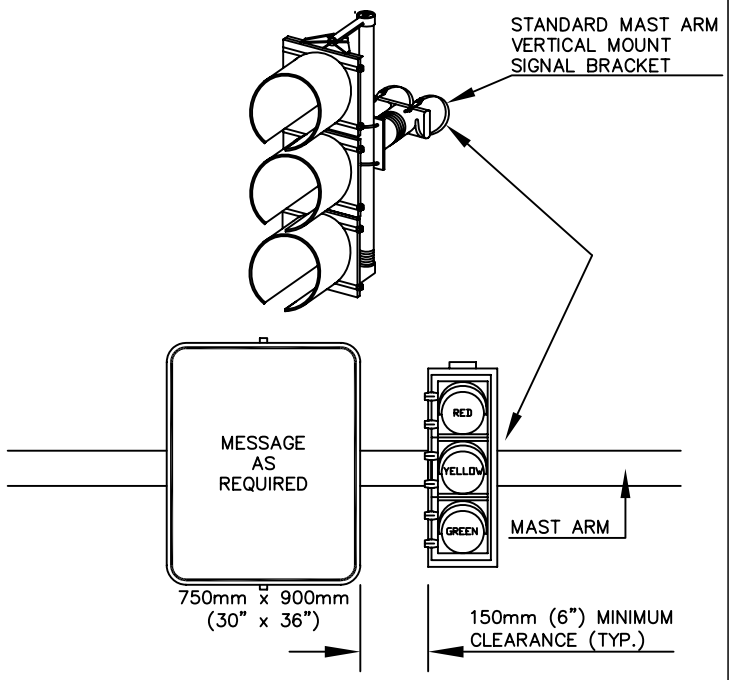

USE THIS MOUNTING BRACKET ONLY WHEN THE SPAN WIRE IS GREATER THAN 10° FROM PERPENDICULAR
360° SWIVEL
RED
YELLOW
GREEN
MESSAGE AS REQUIRED
150mm (6") MINIMUM CLEARANCE (TYP.)
750mm x 900mm (30" x 36")

TYPE II SIGN MOUNT



TYPE III SIGN MOUNT

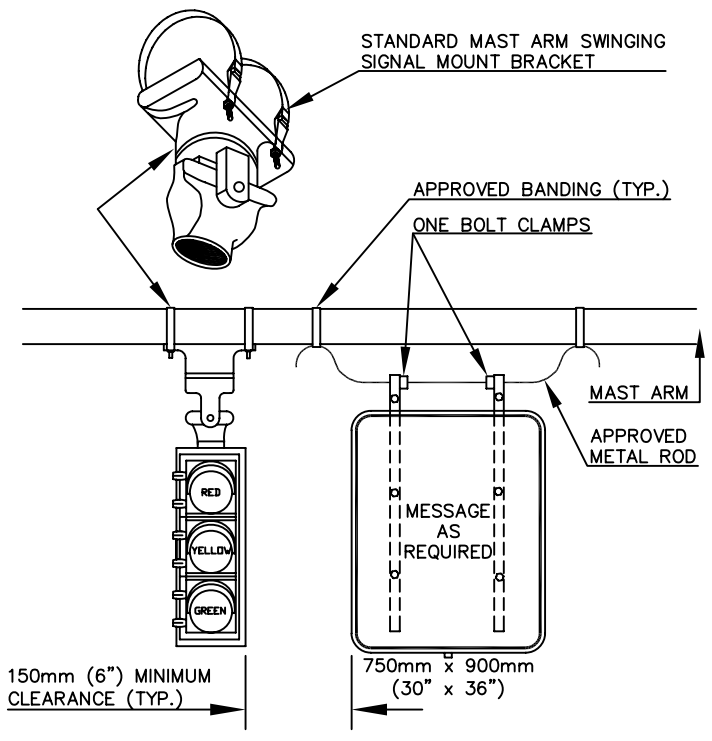
MAST ARM MOUNTED SIGNALS & SIGNS



RIGID MOUNTING

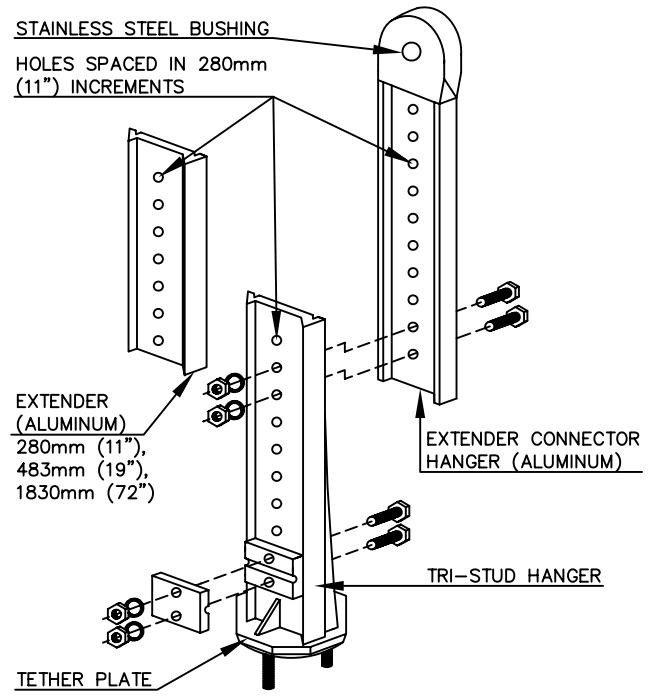
NOTES: ATTACHMENT BRACKETS FOR SIGNS AND SIGNAL HEADS SHALL PERMIT THE POSITIONS OF THE SIGNS AND SIGNALS TO BE ADJUSTED:

1. SO THAT THEY ARE AIMED IN THE REQUIRED DIRECTIONS.
2. SO THAT THEY ARE PLUMB AS VIEWED FROM THEIR RESPECTIVE APPROACHES.
3. SO THAT THE SIGN OR SIGNAL MAY BE TILTED FORWARD OR BACKWARD AS REQUIRED,
4. SO THAT THE SIGN OR SIGNAL MAY BE RAISED OR LOWERED ON THE MAST ARM THROUGHOUT THE FULL HEIGHT OF THE SIGN OR SIGNAL HEAD.

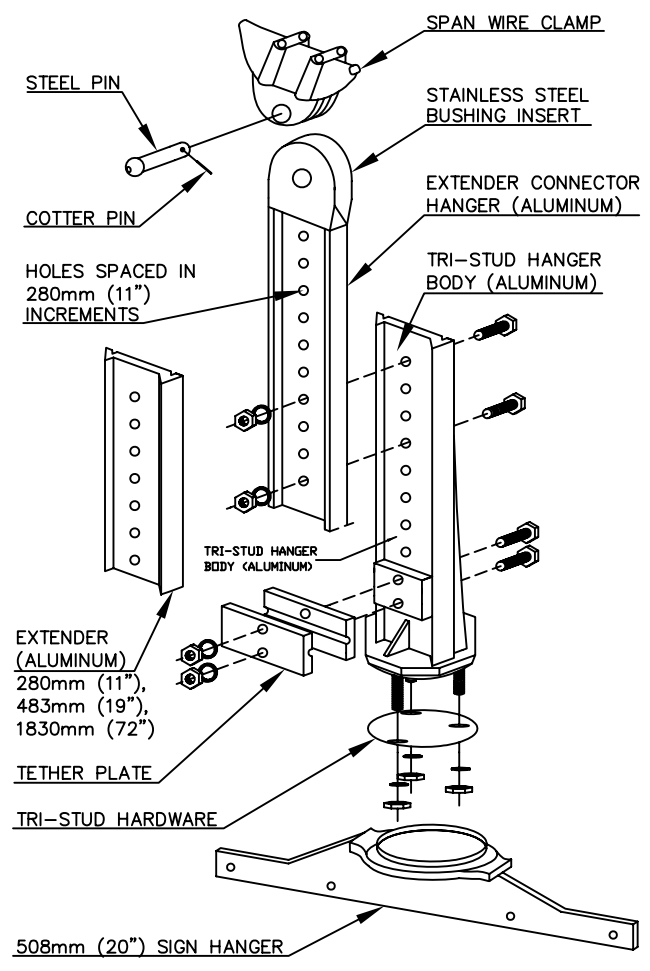


SWINGING MOUNTING

EXTENDER SIGNAL HANGER

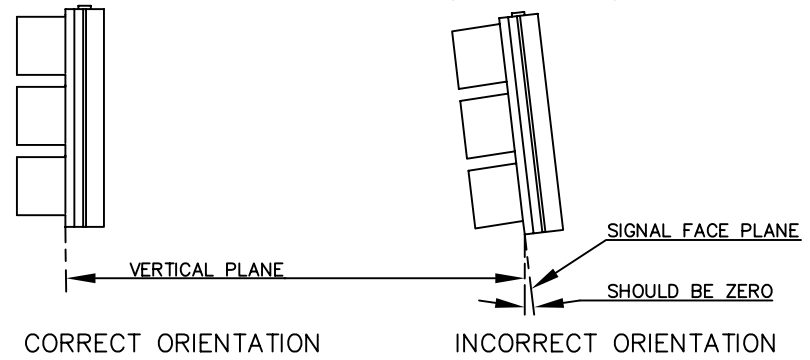

STAINLESS STEEL BUSHING
HOLES SPACED IN 280mm (11") INCREMENTS
EXTENDER (ALUMINUM) 280mm (11"), 483mm (19"), 1830mm (72")
EXTENDER CONNECTOR HANGER (ALUMINUM)
TRI-STUD HANGER
TETHER PLATE

EXTENDER SIGN HANGER

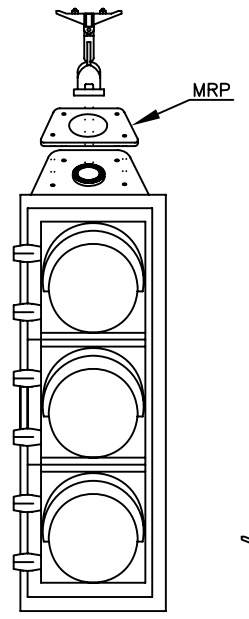


VERTICAL ORIENTATION OF SIGNAL FACES

NOTES: SIGNAL FACES SHALL BE MOUNTED VERTICALLY. WHERE STEEP GRADES ARE INVOLVED, THEY MAY BE TILTED SLIGHTLY AS DIRECTED BY THE ENGINEER.

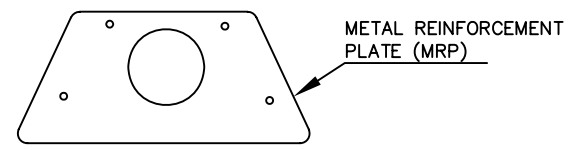


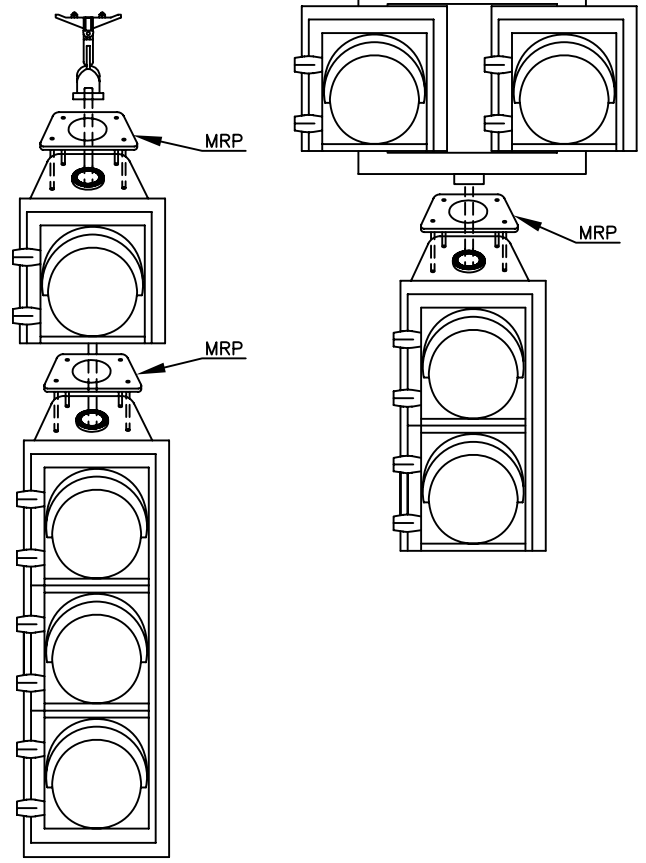
METAL REINFORCEMENT PLATE FOR SIGNAL HEADS



NOTES:

1. METAL REINFORCEMENT PLATES (mrp) SHALL BE INSTALLED ON PLASTIC SIGNAL HEADS AT ALL LOCATIONS SHOWN BELOW.
2. THE METAL REINFORCEMENT PLATE SHALL HAV AN ALUMINUM CONSTRUCTION AND BE APPROVED BY THE ENGINEER.
3. RED SECTION OF 5 SECTION HEAD SHALL BE METAL.





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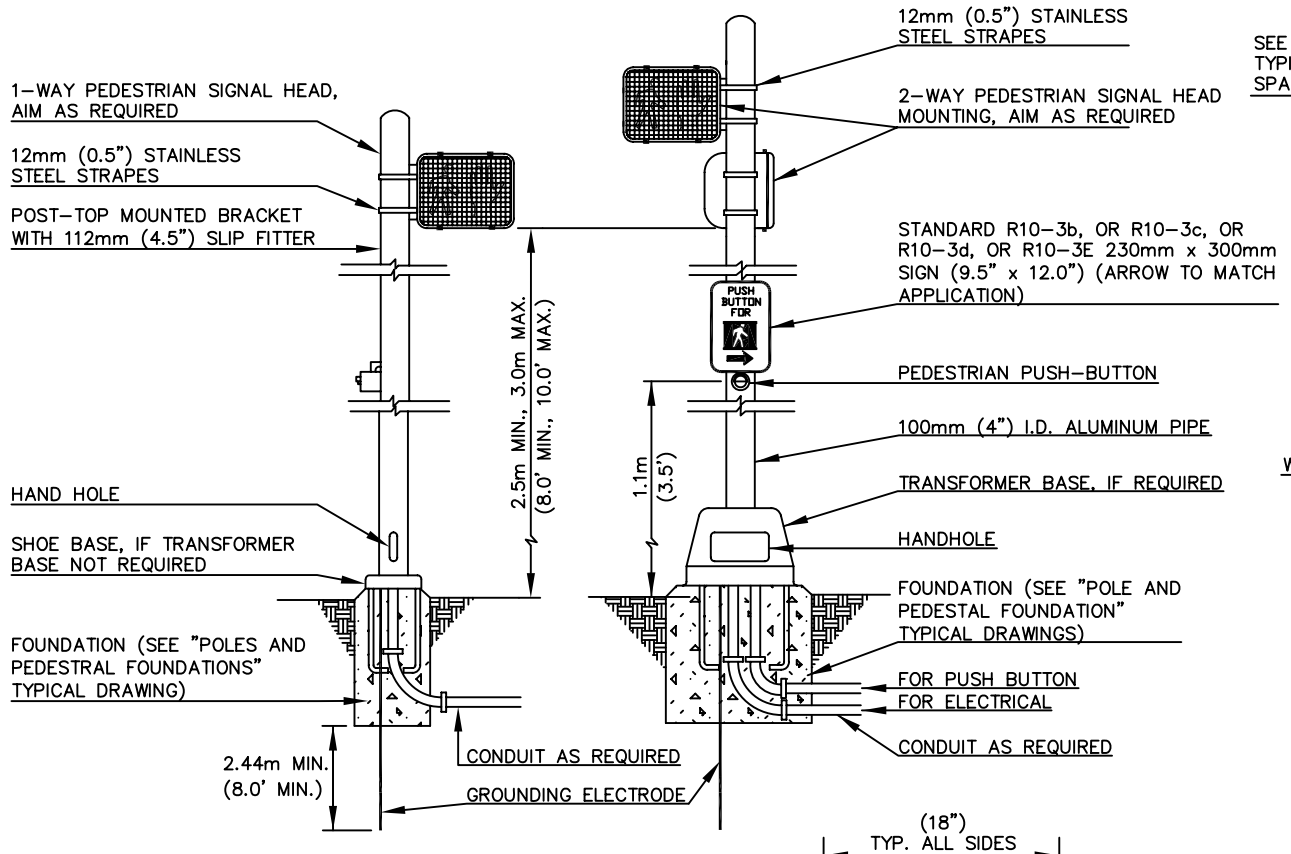
STANDARD DRAWING FOR
OVERHEAD SIGNAL & SIGN INSTALLATION
VERTICAL ORIENTATION OF
SIGNAL FACES

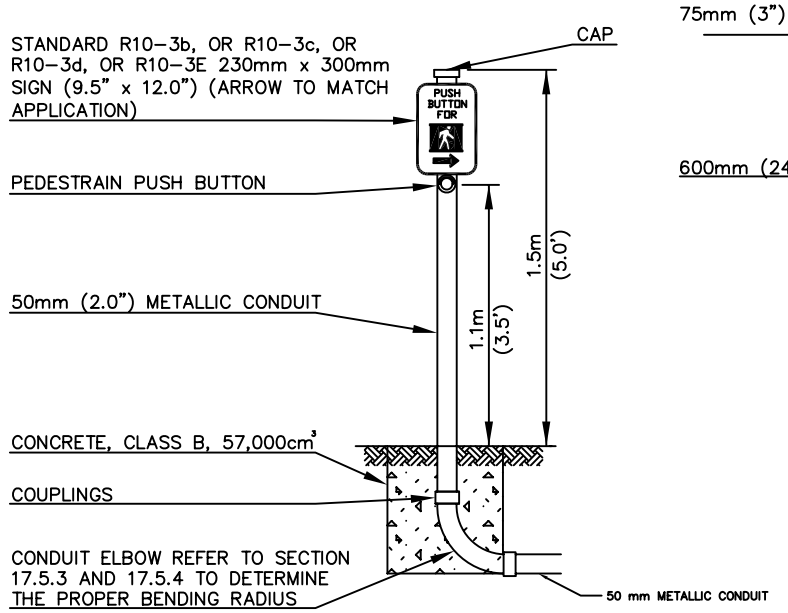
SHEET NO.
SIG-3


1–WAY PEDESTRIAN SIGNAL HEAD, AIM AS REQUIRED
12mm (0.5") STAINLESS STEEL STRAPES
POST–TOP MOUNTED BRACKET WITH 112mm (4.5") SLIP FITTER
12mm (0.5") STAINLESS STEEL STRAPES
2–WAY PEDESTRIAN SIGNAL HEAD MOUNTING, AIM AS REQUIRED
STANDARD R10–3b, OR R10–3c, OR R10–3d, OR R10–3E 230mm x 300mm SIGN (9.5" x 12.0") (ARROW TO MATCH APPLICATION)
PUSH BUTTON FOR
PEDESTRIAN PUSH–BUTTON
100mm (4") I.D. ALUMINUM PIPE
TRANSFORMER BASE, IF REQUIRED
HANDHOLE
FOUNDATION (SEE "POLE AND PEDESTAL FOUNDATION" TYPICAL DRAWINGS)
FOR PUSH BUTTON
FOR ELECTRICAL
CONDUIT AS REQUIRED
CONDUIT AS REQUIRED
GROUNDING ELECTRODE
HAND HOLE
SHOE BASE, IF TRANSFORMER BASE NOT REQUIRED
FOUNDATION (SEE "POLES AND PEDESTRAL FOUNDATIONS" TYPICAL DRAWING)
2.5m MIN., 3.0m MAX. (8.0' MIN., 10.0' MAX.)
1.1m (3.5')
2.44m MIN. (8.0' MIN.)
(18") TYP. ALL SIDES

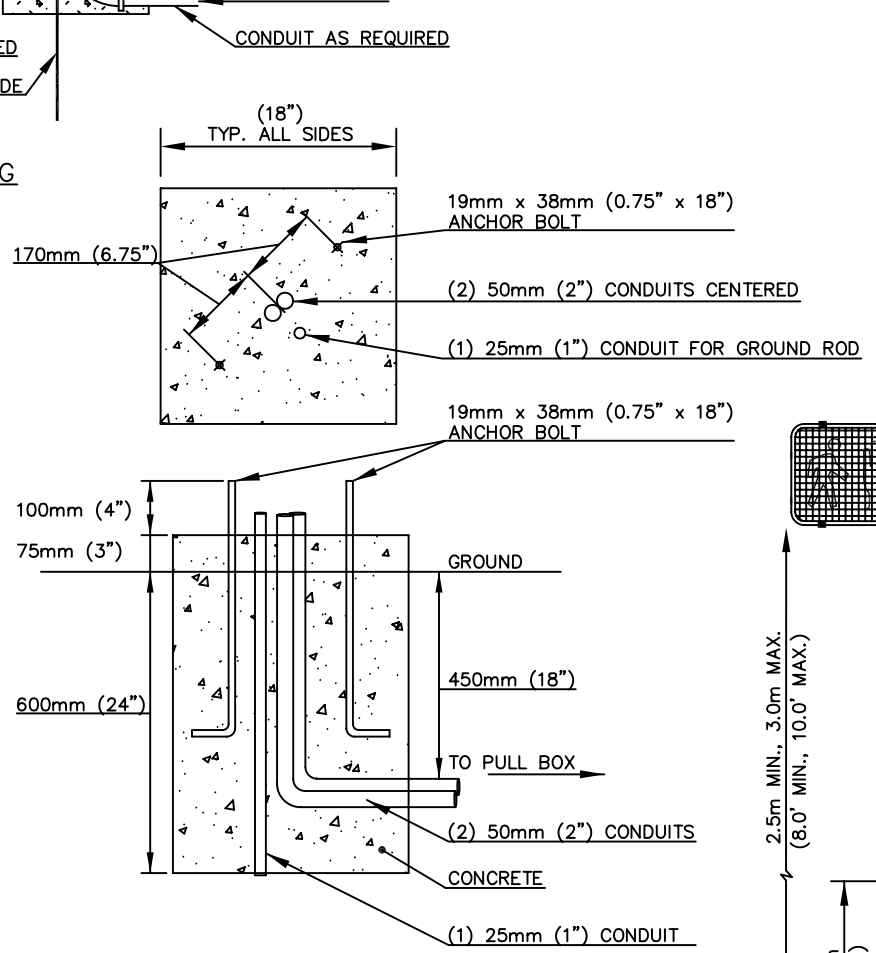
PEDESTAL MOUNTING

NOTES:

1. BOND ALL METAL CONDUITS WITH A SINGLE, CONTINUOUS SOLID COPPER GROUND WIRE TO THE GROUNDING ELECTRODE, THE PUSH–BUTTON HOUSING AND THE PECESTAL GROUND LUG.
2. CONNECT PUSH–BUTTON TO CONTROLLER CABINET USING PEDESTRIAN PUSH–BUTTON CABLE.


STANDARD R10–3b, OR R10–3c, OR R10–3d, OR R10–3E 230mm x 300mm SIGN (9.5" x 12.0") (ARROW TO MATCH APPLICATION)
CAP
PUSH BUTTON FOR
PEDESTRAIN PUSH BUTTON
50mm (2.0") METALLIC CONDUIT
1.5m (5.0')
1.1m (3.5')
CONCRETE, CLASS B, 57,000cm³
COUPLINGS
CONDUIT ELBOW REFER TO SECTION 17.5.3 AND 17.5.4 TO DETERMINE THE PROPER BENDING RADIUS
50 mm METALLIC CONDUIT

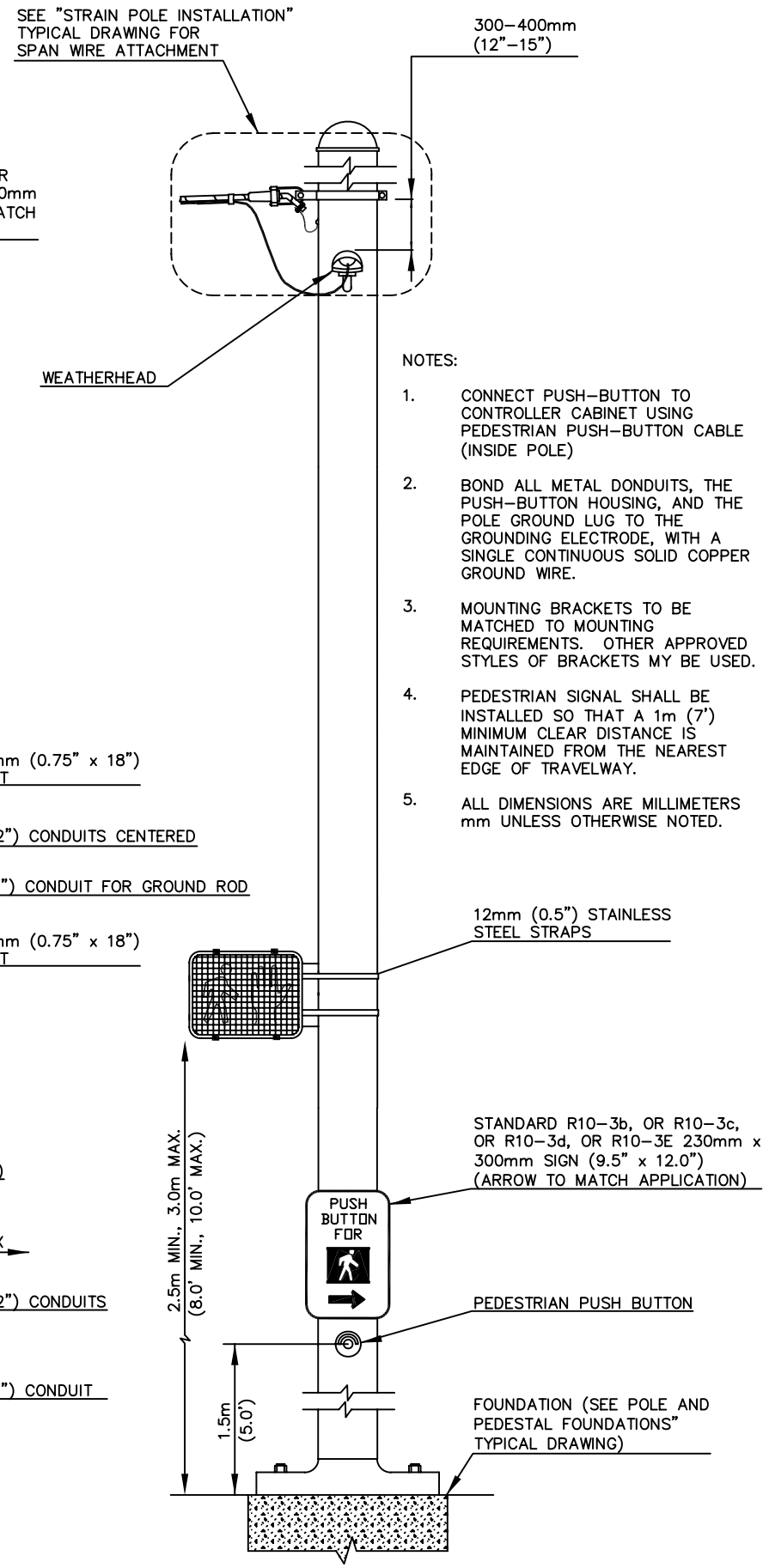
POST MOUNTING OF PUSH BUTTON



PEDESTRIAN BASE

NOTES:

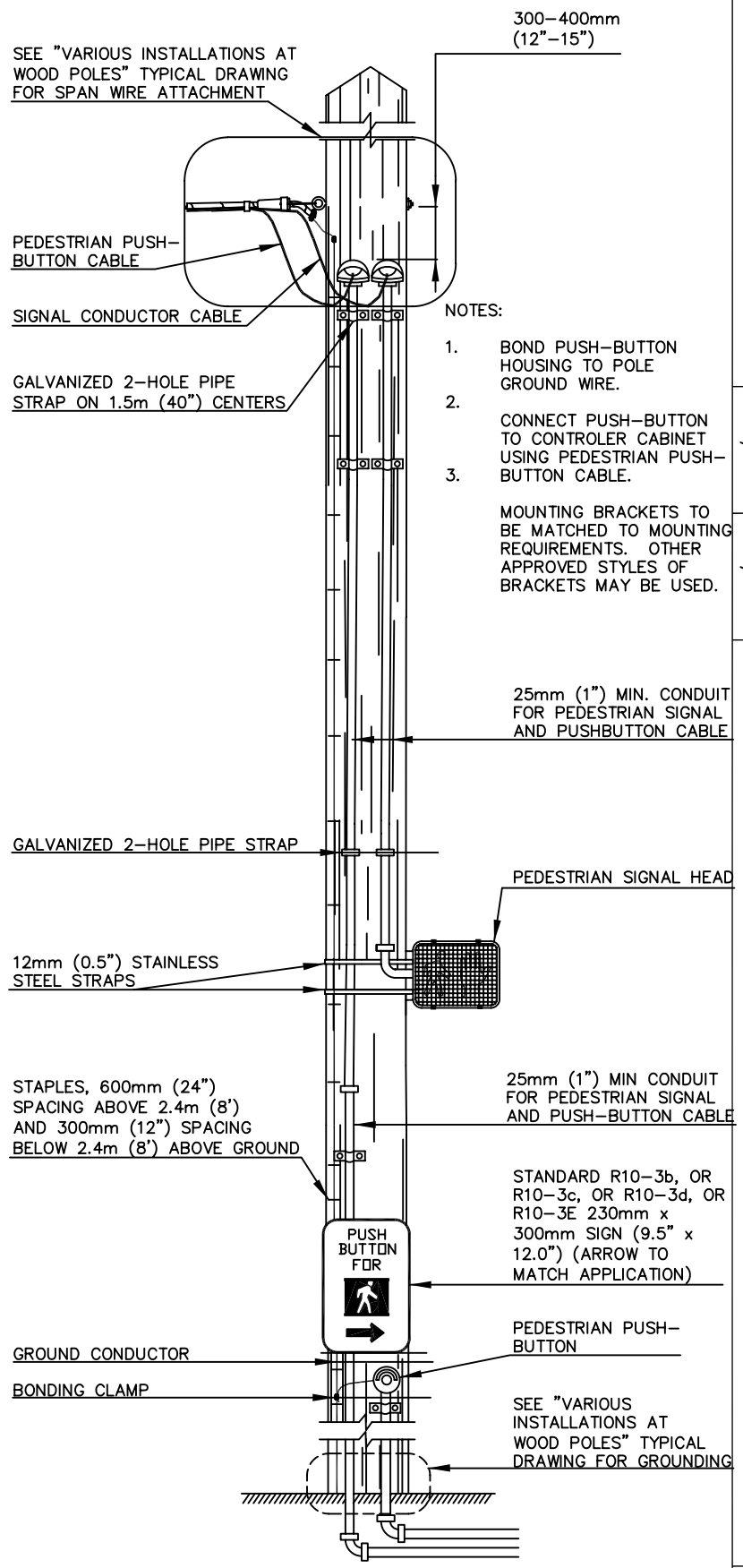
1. CABINET USING PEDESTRIAN PUSH–BUTTON CABLE.
2. GROUND CASE OF PUSH–BUTTON TO CONTROL CABINET GROUND BUS VIA GROUNDING COUNDUCTOR IN PUSH–BUTTON SIGNAL CABLE


SEE "STRAIN POLE INSTALLATION" TYPICAL DRAWING FOR SPAN WIRE ATTACHMENT
300–400mm (12"–15")
WEATHERHEAD
12mm (0.5") STAINLESS STEEL STRAPS
STANDARD R10–3b, OR R10–3c, OR R10–3d, OR R10–3E 230mm x 300mm SIGN (9.5" x 12.0") (ARROW TO MATCH APPLICATION)
PUSH BUTTON FOR
PEDESTRIAN PUSH BUTTON
2.5m MIN., 3.0m MAX. (8.0' MIN., 10.0' MAX.)
1.5m (5.0')
FOUNDATION (SEE POLE AND PEDESTAL FOUNDATIONS" TYPICAL DRAWING)

NOTES:

1. CONNECT PUSH–BUTTON TO CONTROLLER CABINET USING PEDESTRIAN PUSH–BUTTON CABLE (INSIDE POLE)
2. BOND ALL METAL DONDUITS, THE PUSH–BUTTON HOUSING, AND THE POLE GROUND LUG TO THE GROUNDING ELECTRODE, WITH A SINGLE CONTINUOUS SOLID COPPER GROUND WIRE.
3. MOUNTING BRACKETS TO BE MATCHED TO MOUNTING REQUIREMENTS. OTHER APPROVED STYLES OF BRACKETS MY BE USED.
4. PEDESTRIAN SIGNAL SHALL BE INSTALLED SO THAT A 1m (7') MINIMUM CLEAR DISTANCE IS MAINTAINED FROM THE NEAREST EDGE OF TRAVELWAY.
5. ALL DIMENSIONS ARE MILLIMETERS mm UNLESS OTHERWISE NOTED.

STEEL POLE MOUNTING


SEE "VARIOUS INSTALLATIONS AT WOOD POLES" TYPICAL DRAWING FOR SPAN WIRE ATTACHMENT
300–400mm (12"–15")
PEDESTRIAN PUSH–BUTTON CABLE
SIGNAL CONDUCTOR CABLE
GALVANIZED 2–HOLE PIPE STRAP ON 1.5m (40") CENTERS
25mm (1") MIN. CONDUIT FOR PEDESTRIAN SIGNAL AND PUSHBUTTON CABLE
GALVANIZED 2–HOLE PIPE STRAP
PEDESTRIAN SIGNAL HEAD
12mm (0.5") STAINLESS STEEL STRAPS
STAPLES, 600mm (24") SPACING ABOVE 2.4m (8') AND 300mm (12") SPACING BELOW 2.4m (8') ABOVE GROUND
25mm (1") MIN CONDUIT FOR PEDESTRIAN SIGNAL AND PUSH–BUTTON CABLE
STANDARD R10–3b, OR R10–3c, OR R10–3d, OR R10–3E 230mm x 300mm SIGN (9.5" x 12.0") (ARROW TO MATCH APPLICATION)
PUSH BUTTON FOR
PEDESTRIAN PUSH–BUTTON
GROUND CONDUCTOR
BONDING CLAMP
SEE "VARIOUS INSTALLATIONS AT WOOD POLES" TYPICAL DRAWING FOR GROUNDING

NOTES:

1. BOND PUSH–BUTTON HOUSING TO POLE GROUND WIRE.
2. CONNECT PUSH–BUTTON TO CONTROLER CABINET USING PEDESTRIAN PUSH–BUTTON CABLE.
3. MOUNTING BRACKETS TO BE MATCHED TO MOUNTING REQUIREMENTS. OTHER APPROVED STYLES OF BRACKETS MAY BE USED.

WOOD POLE MOUNTING

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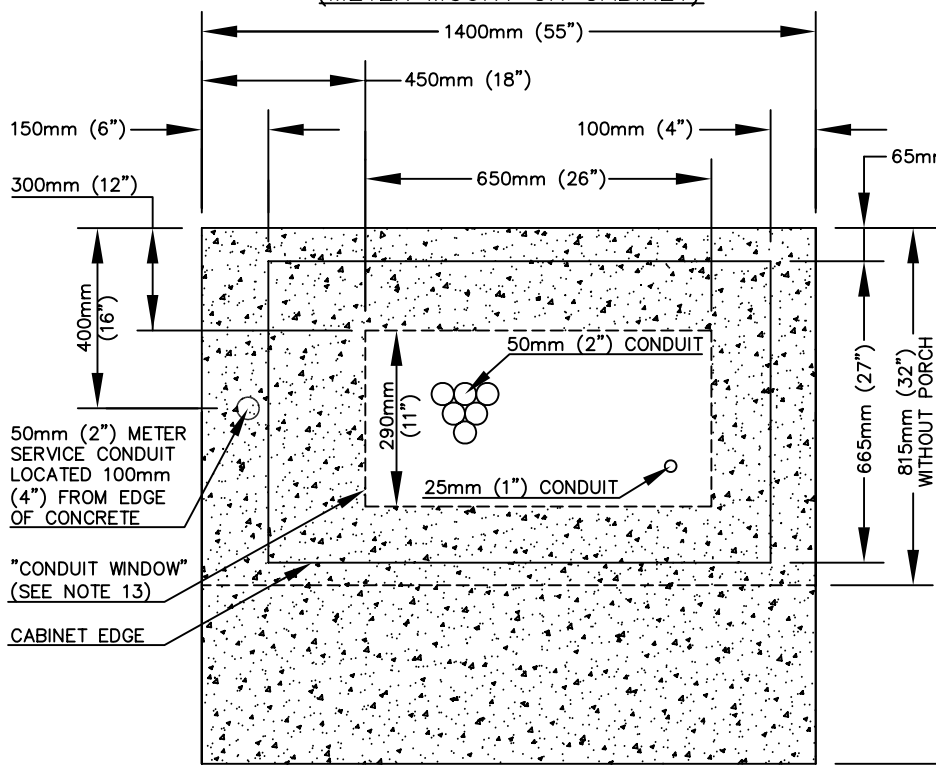
	03/01

STANDARD DRAWING FOR PEDESTRIAN SIGNAL AND PUSH BUTTON INSTALLATION

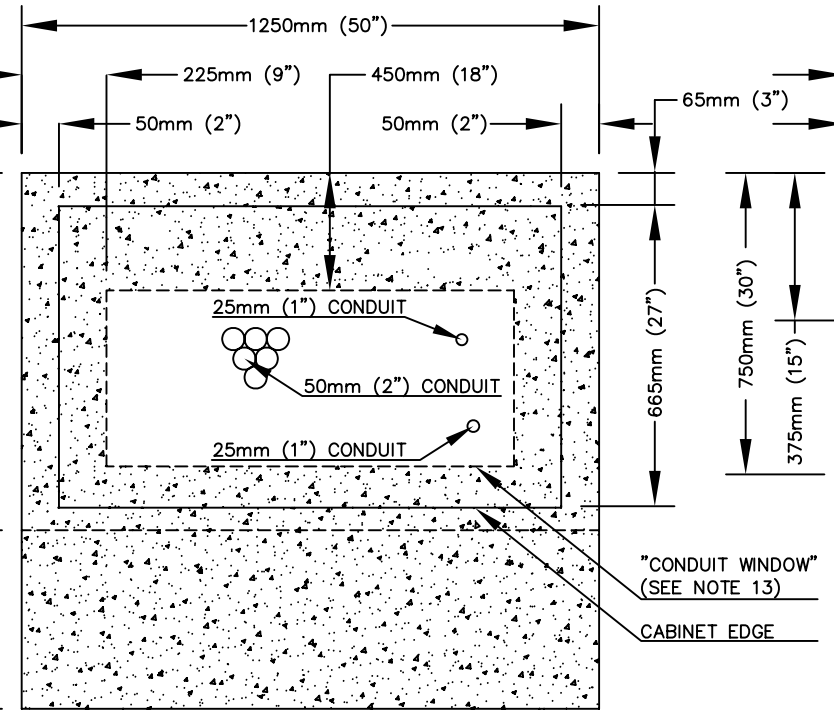
SHEET NO.
SIG–4

TYPE "P" CABINET
(METER MOUNT ON CABINET)



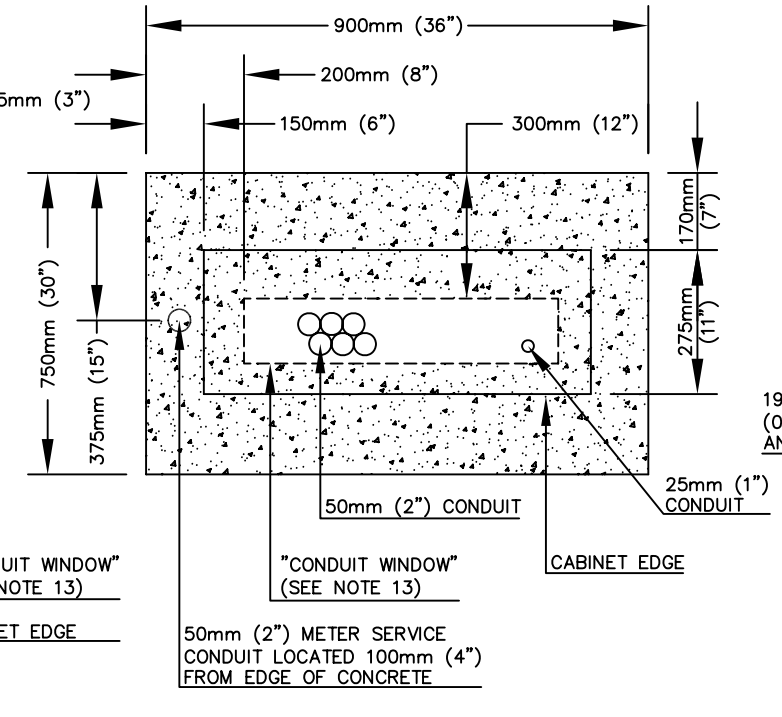
TOP VIEW

TYPE "P" CABINET
(METER MOUNT ON POLE)



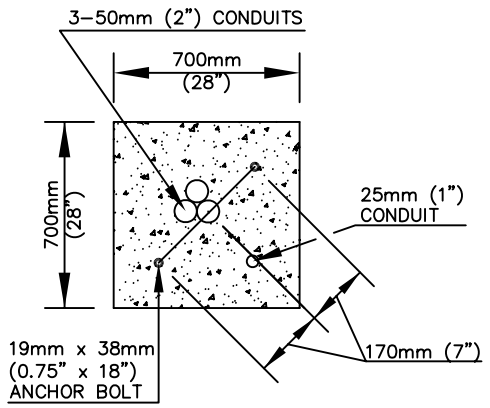
TOP VIEW

TYPE "K" OR TYPE "M" CABINET
(METER MOUNT ON CABINET)

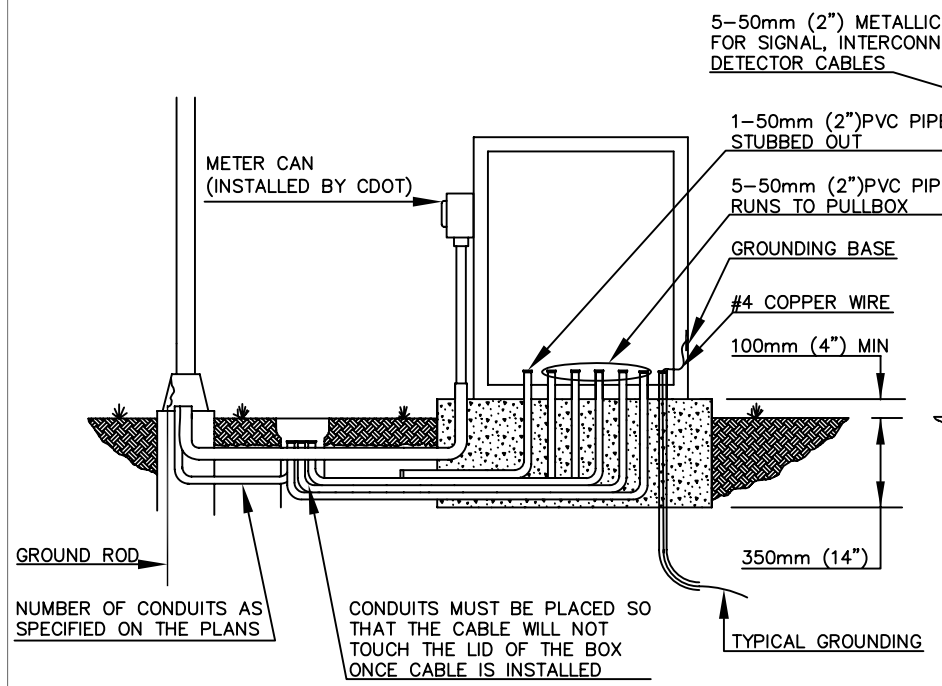


TOP VIEW

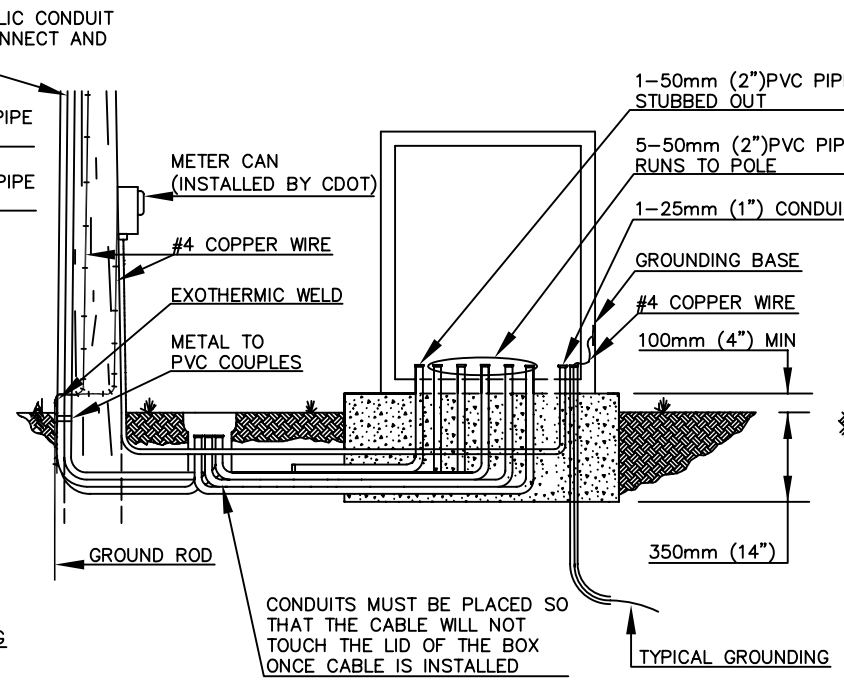
PEDESTAL MOUNT CABINET



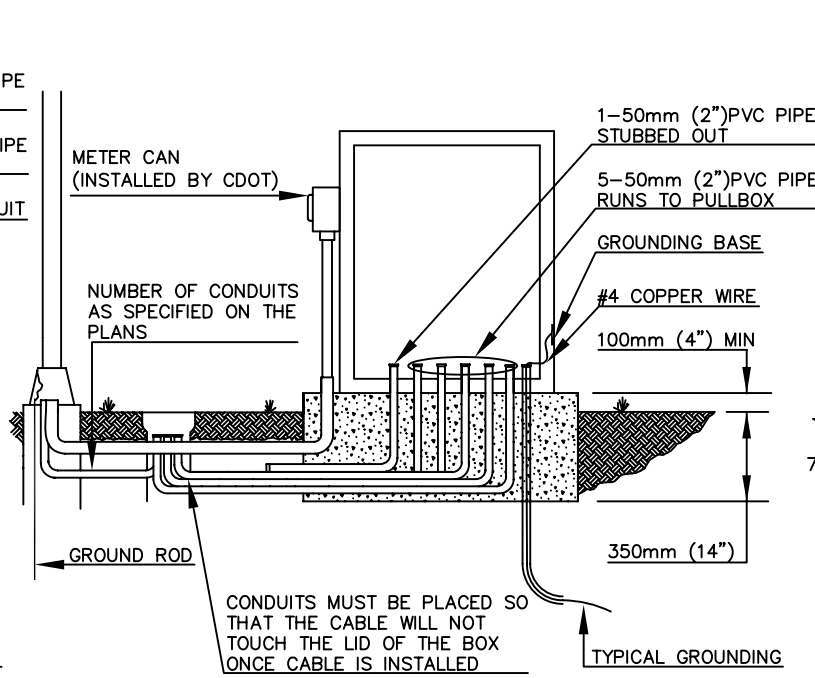
TOP VIEW


5-50mm (2") METALLIC CONDUIT FOR SIGNAL, INTERCONNECT AND DETECTOR CABLES
METER CAN (INSTALLED BY CDOT)
1-50mm (2")PVC PIPE STUBBED OUT
5-50mm (2")PVC PIPE RUNS TO PULLBOX
GROUNDING BASE
#4 COPPER WIRE
100mm (4") MIN
350mm (14")
GROUND ROD
NUMBER OF CONDUITS AS SPECIFIED ON THE PLANS
CONDUITS MUST BE PLACED SO THAT THE CABLE WILL NOT TOUCH THE LID OF THE BOX ONCE CABLE IS INSTALLED
TYPICAL GROUNDING

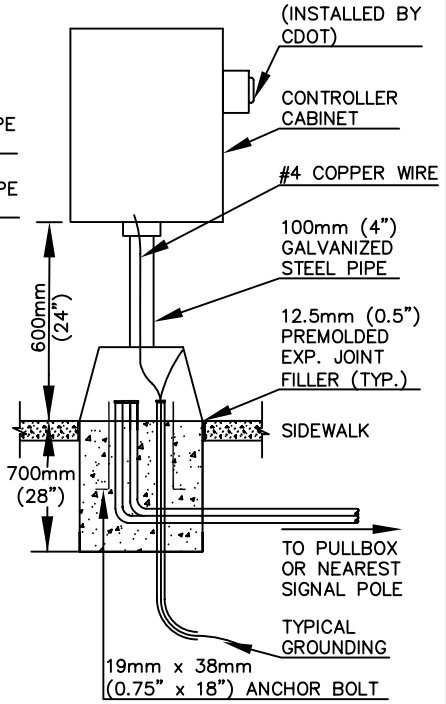
SIDE VIEW


METER CAN (INSTALLED BY CDOT)
#4 COPPER WIRE
EXOTHERMIC WELD
METAL TO PVC COUPLES
1-50mm (2")PVC PIPE STUBBED OUT
5-50mm (2")PVC PIPE RUNS TO POLE
1-25mm (1") CONDUIT
GROUNDING BASE
#4 COPPER WIRE
100mm (4") MIN
350mm (14")
GROUND ROD
CONDUITS MUST BE PLACED SO THAT THE CABLE WILL NOT TOUCH THE LID OF THE BOX ONCE CABLE IS INSTALLED
TYPICAL GROUNDING

SIDE VIEW


METER CAN (INSTALLED BY CDOT)
NUMBER OF CONDUITS AS SPECIFIED ON THE PLANS
1-50mm (2")PVC PIPE STUBBED OUT
5-50mm (2")PVC PIPE RUNS TO PULLBOX
GROUNDING BASE
#4 COPPER WIRE
100mm (4") MIN
350mm (14")
GROUND ROD
CONDUITS MUST BE PLACED SO THAT THE CABLE WILL NOT TOUCH THE LID OF THE BOX ONCE CABLE IS INSTALLED
TYPICAL GROUNDING

SIDE VIEW



SIDE VIEW

NOTES:

1. CONDUITS TURNED UP IN THE SLAB SHALL BE INSIDE THE "CONDUIT WINDOW". 90° ELBOWS TO BE A SWEEPING RADIUS NOT STANDARD 90°.
2. CONDUITS SHALL BE STUBBED 100mm (4") ABOVE THE GROUND OR SLAB.
3. CONDUIT STUBS SHALL BE TURNED UP FLUSH WITH AND PARALLEL TO THE UTILITY POLE.
4. ALL CONDUIT STUBS SHALL BE CAPPED PRIOR TO PLACING CONCRETE FOR THE SLAB (CAPS SHALL NOT BE GLUED).
5. ALL CONDUIT JOINTS ARE TO BE CLEANED AND GLUED.
6. USE 3600 psi (MINIMUM) CONCRETE WITH STANDARD GRAVEL AND 2% (MAXIMUM) CALCIUM CHLORIDE.
7. INSTALL A MINIMUM OF THESE GROUND RODS. ENSURE THAT EXISTING UNDERGROUND FACILITIES ARE NOT DAMAGED DURING INSTALLATION.
8. MAKE TEMPORARY CONNECTIONS WITH COMPRESSION CLAMPS.
9. TEST GROUNDING SYSTEM USING AN APPROVED METHOD. IF THE RESISTANCE MEASUREMENT IS GREATER THAN 20 OHMS, ADDITIONAL GROUND RODS SHALL BE INSTALLED AS DIRECTED BY THE ENGINEER. SYSTEM SHOULD MEASURE LESS THAN 20 OHMS.
10. ALL UNDERGROUND BOND OF GROUNDING ELECTRODES AND CONDUCTORS SHALL BE BY AN EXOTHERMIC WELDING PROCESS (CADWELD OR EQUIVALENT).
11. DETECTABLE BURIAL TAPE SHALL BE PLACED DIRECTLY ABOVE ALL GROUNDING ELECTRODES AND CONDUCTORS, AND SHALL BE BURIED AT A DEPTH OF 12"-18".
12. ALL UNITS ARE IN MILLIMETERS "mm". ENGLISH MEASUREMENTS ARE ALSO SHOWN (").
13. PLACE 1" WASHED CRUSHED STONE AT A DEPTH OF 12" IN THE CONDUIT AREA.

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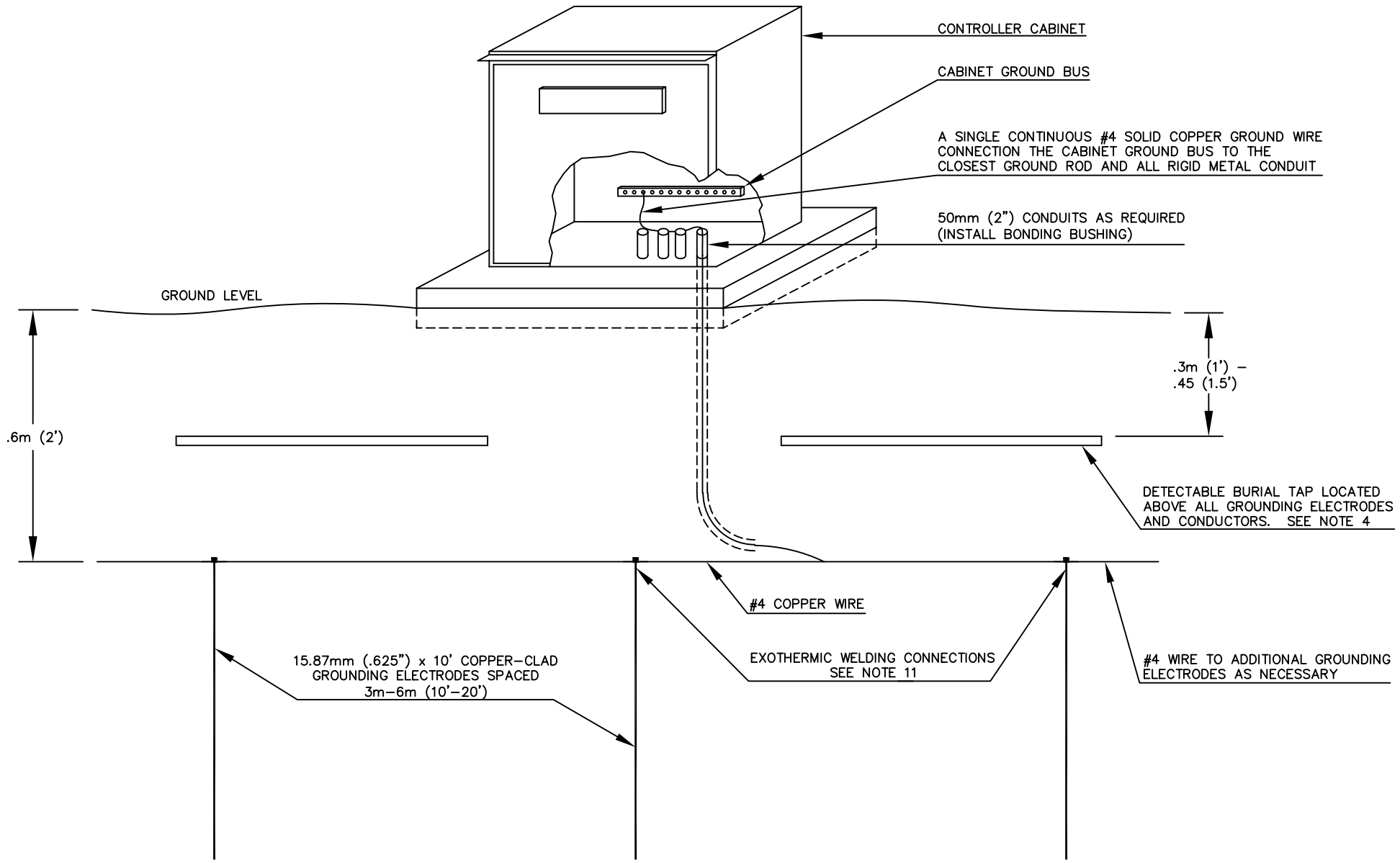
STANDARD DRAWING FOR CONTROL EQUIPMENT CABINET GROUNDING AND INSTALLATION

SHEET NO.
SIG-5
1 OF 2

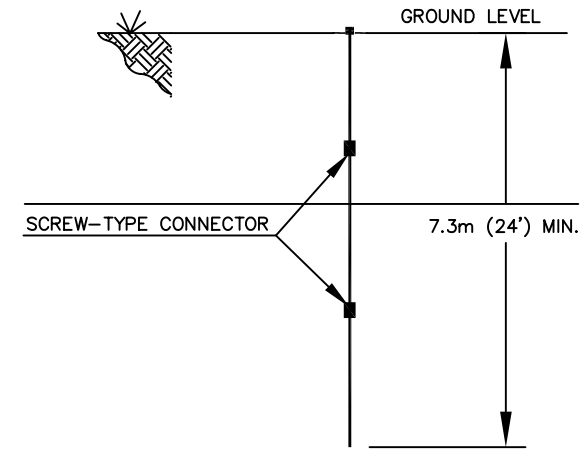

CONTROLLER CABINET
CABINET GROUND BUS
A SINGLE CONTINUOUS #4 SOLID COPPER GROUND WIRE CONNECTION THE CABINET GROUND BUS TO THE CLOSEST GROUND ROD AND ALL RIGID METAL CONDUIT
50mm (2") CONDUITS AS REQUIRED (INSTALL BONDING BUSHING)
GROUND LEVEL
.6m (2')
.3m (1') – .45 (1.5')
DETECTABLE BURIAL TAP LOCATED ABOVE ALL GROUNDING ELECTRODES AND CONDUCTORS. SEE NOTE 4
#4 COPPER WIRE
EXOTHERMIC WELDING CONNECTIONS SEE NOTE 11
#4 WIRE TO ADDITIONAL GROUNDING ELECTRODES AS NECESSARY
15.87mm (.625") x 10' COPPER-CLAD GROUNDING ELECTRODES SPACED 3m-6m (10'-20')

NOTES:

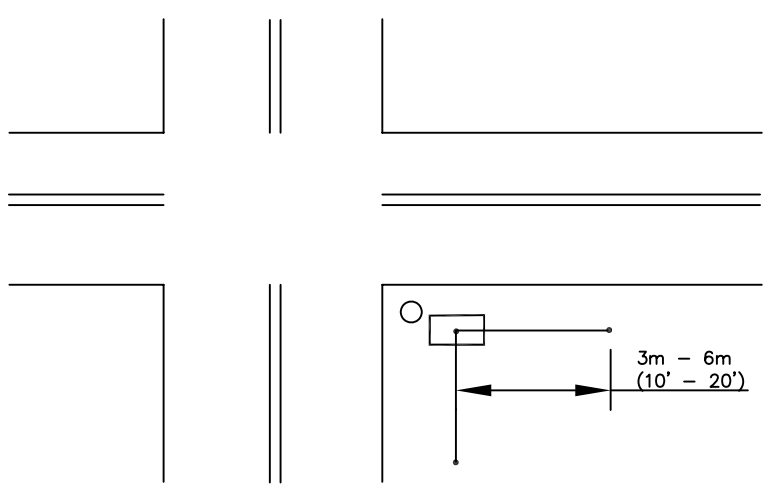
1. INSTALL A MINIMUM OR THREE (3) GROUND RODS SPACED AS SHOWN. ENSURE THAT EXISTING UNDERGROUND FACILITIES ARE NOT DAMAGED DURING INSTALLATION.
2. MAKE TEMPORARY CONNECTION WITH COMPRESSION CLAMPS.
3. TEST GROUNDING SYSTEM USING AN APPROVED METHOD. SYSTEM SHOULD MEASURE LESS THAN TWENTY (20) OMHS. IF THE RESISTANCE MEASUREMENT IS GREATER THAN TWENTY (20) OMHS, ADDITIONAL GROUND RODS SHALL BE INSTALLED AS DIRECTED BY THE ENGINEER TO FULFILL THIS REQUIREMENT.
4. ALL UNDERGROUND BONDING OF GROUNDING ELECTRODES AND CONDUCTORS SHALL BE BY AN EXOTHERMIC WELDING PROCESS (CALDWELL OR EQUIVALENT).
5. DETECTABLE BURIAL TAPE SHALL BE PLACED DIRECTLY ABOVE ALL GROUNDING ELECTRODES AND CONDUCTORS AND SHALL BE BURIED AT A DEPTH OF 0.3-0.45m (1'-1.5').

ALTERNATE CONSTRUCTION

IF SPACE IS NOT AVAILABLE TO DRIVE MULTIPLE GROUND RODS, DRIVE SECTIONAL GROUND RODS A MIN. OF 7.3m (24').

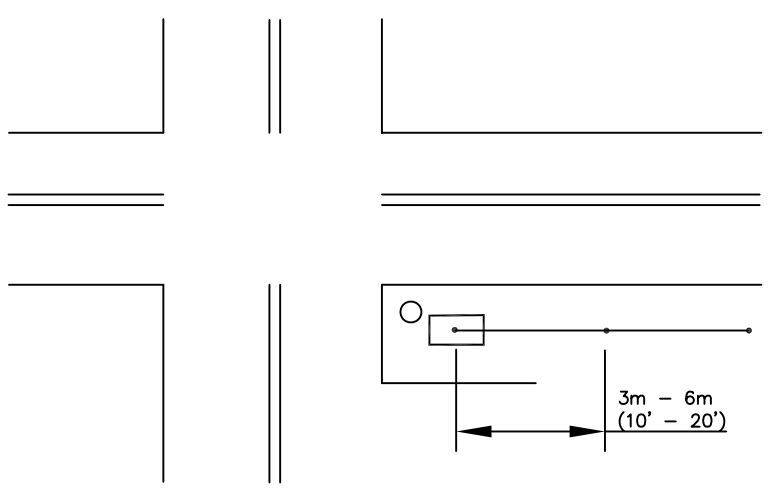


GROUND ROD LAYOUT



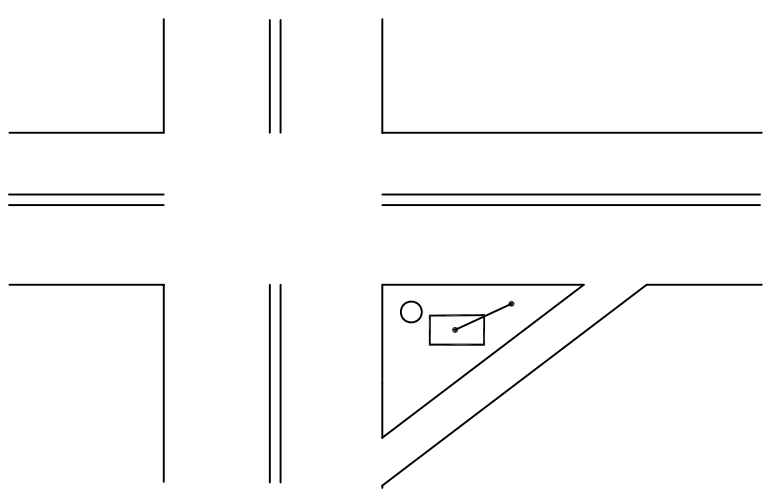
UNRESTRICTED SHOULDER

3 OR MORE 3.05m (10') GROUNDING ELECTRODES ARE SPACED 3m – 6m (10' – 20') MINIMUM APART AND ARE PLACED AT 90° OR IN A STRAIGHT LINE FROM EACH OTHER.



LIMITED SHOULDER

3 OR MORE 3.05m (10') GROUNDING ELECTRODES ARE PLACED IN A STRAIGHT LINE AND ARE SPACED 3m – 6m (10' – 20') MINIMUM APART.



RESTRICTED SPACE

DRIVEN TO A DEPTH OF AT LEAST 7.3m AND PLACED AT THE CABINET

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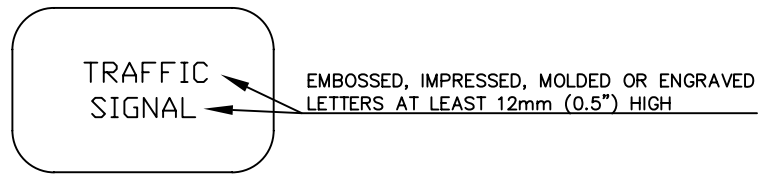
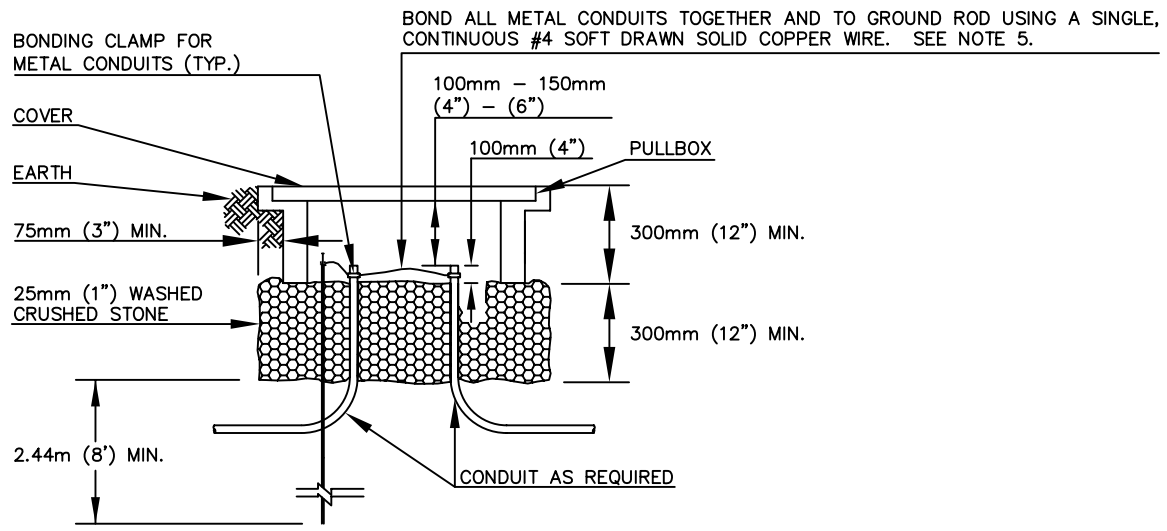
STANDARD DRAWING FOR
CONTROL EQUIPMENT CABINET GROUNDING

SHEET NO.
SIG-5
2 OF 2

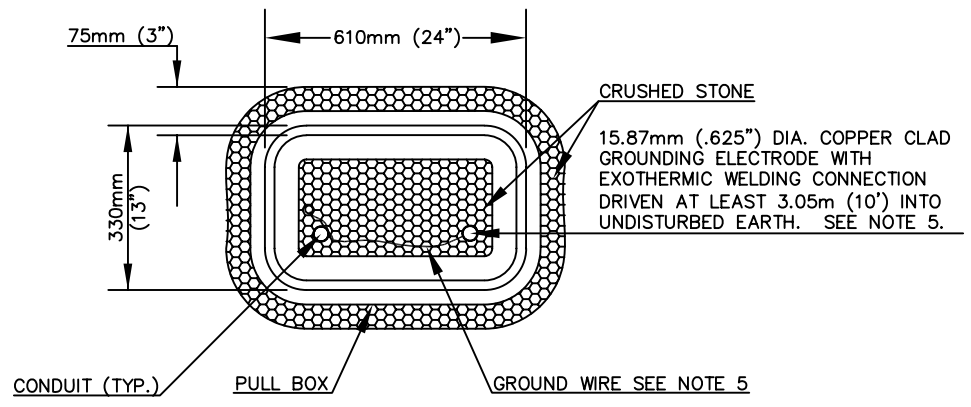
SIZE (LxWxD):	TYPE:	MATERIAL:
13" x 24" x 12"	LOOPS PULLBOX	FIBER REINFORCED POLYMER CONCRETE
17" x 30" x 24"	FIBER OPTIC PULLBOX	FIBER REINFORCED POLYMER CONCRETE
24" x 36" x 24"	CONTROLLER PULLBOX A	FIBER REINFORCED POLYMER CONCRETE
30" x 48" x 36"	CONTROLLER PULLBOX B	FIBER REINFORCED POLYMER CONCRETE
24" x 24" x 12"	CONTROLLER PULLBOX C	CONCRETE WITH METAL LID
36" x 36" x 12"	CONTROLLER PULLBOX D	CONCRETE WITH METAL LID



TOP VIEW OF COVER



INSTALLATION CROSS–SECTION

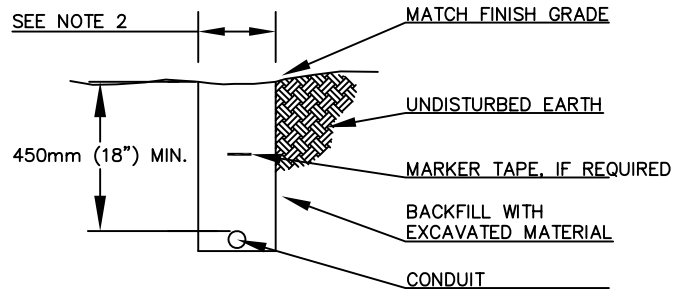


INSTALLED TOP VIEW (WITHOUT COVER)

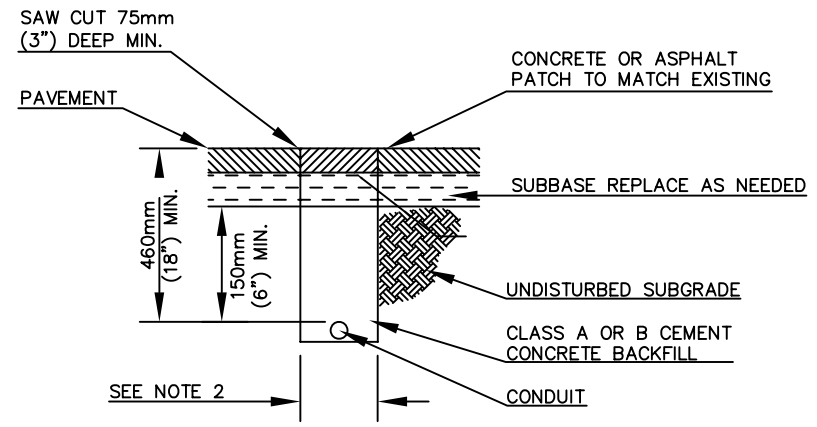
NOTES:

1. OTHER STYLES OF PULL BOX WILL BE ACCEPTABLE PROVIDED THEY SATISFY THE REQUIREMENTS OF THE TRAFFIC SIGNAL SPECIFICATIONS AND THE MINIMUM DIMENSIONS.
2. COVER SHALL HAVE A PULL–UP SLOT AND TWO HEX BOLTS TO SECURE IT TO BODY OF BOX.
3. NUMBER AND SIZES OF CONDUITS SHALL BE AS REQUIRED BY THE PLANS. NO MORE THAN 8 CONDUITS SHALL ENTER A PULLBOX UNLESS APPROVED BY CDOT. NO MORE THAN 3 OR THOSE CONDUITS SHALL BE 50mm (2") OR LARGER.
4. THE PULL BOX SHALL WITHSTAND THE LOADS DEFINED IN THE TRAFFIC SIGNAL SPECIFICATIONS.
5. GROUNDING ELECTRODE AND GROUND WIRE REQUIRED ONLY IF THE PULL BOX CONTAINS METALLIC CONDUITS WITH CIRCUITS HAVING VOLTAGES GREATER THAN 24 VOLTS AND ONLY IF CONDUITS NOT OTHERWISE GROUNDED WITHIN 300 LINEAR METERS.
6. ALL DIMENSIONS ARE MILLIMETERS "mm". ENGLISH MEASUREMENTS ARE ALSO SHOWN (").
7. FOR LOCATIONS OF LOOP PULL BOXES SEE SHEET NO. SIG–9 FIGURE 4.
8. ALL CONDUITS TO BE SCHEDULE 40 PVC OR HDPE DEPENDING ON USE AS DECIDED BY CDOT REPRESENTATIVE.

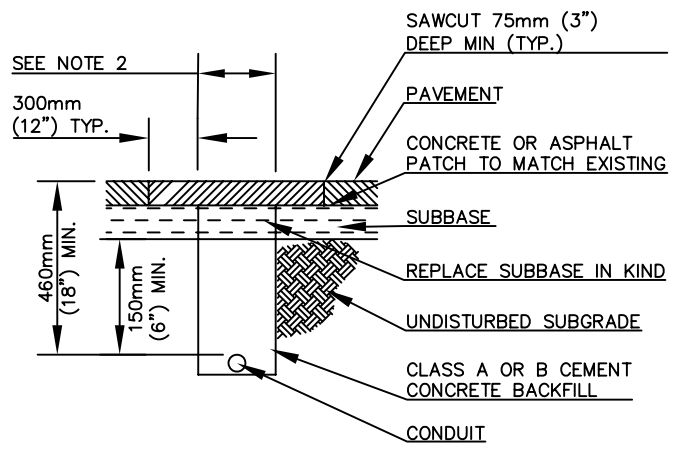
PULL (JUNCTION) BOX
DESIGN AND INSTALLATION



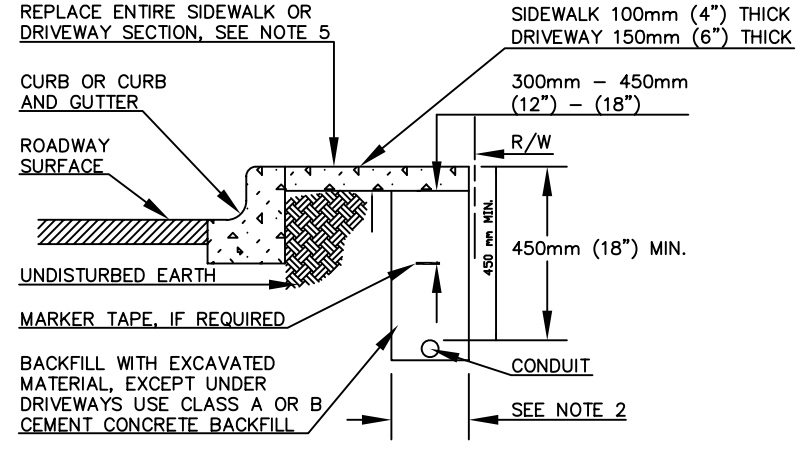
IN EARTH



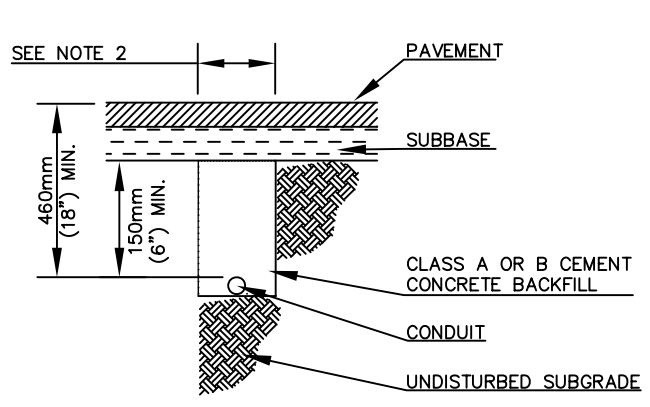
IN PAVED SHOULDER



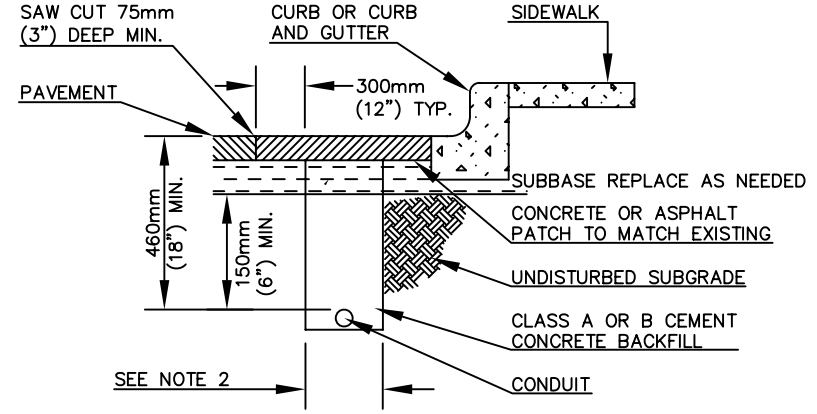
IN EXISTING PAVEMENT (NOT AT GUTTER)



IN SIDEWALK OR DRIVEWAY



IN NEW PAVEMENT



IN EXISTING PAVEMENT (AT GUTTER)

NOTES:

1. CONDUIT AND ITS INSTALLATION SHALL CONFORM TO THE REQUIREMENTS OF THE TRAFFIC SIGNAL SPECIFICATIONS.
2. THE WIDTH OF THE TRENCH SHALL BE ADEQUATE TO ACCEPT THE REQUIRED CONDUITS AND TO PERMIT PROPER COMPACTION.
3. IF MORE THAN ONE CONDUIT IN TRENCH, SEPARATE BY AN LEAST 25mm (1").
4. THE REMOVAL OF PAVEMENT BEYOND THE EDGES OF THE TRENCH, AS SHOWN, WILL NOT BE REQUIRED IF SAID EDGES ARE SAW CUT AND MAINTAINED NEATLY WITH NO SHATTER.
5. ALL DIMENSIONS ARE MILLIMETERS "mm". ENGLISH MEASUREMENTS ARE ALSO SHOWN (").

CONDUIT INSTALLATION

CITY OF CHARLOTTE
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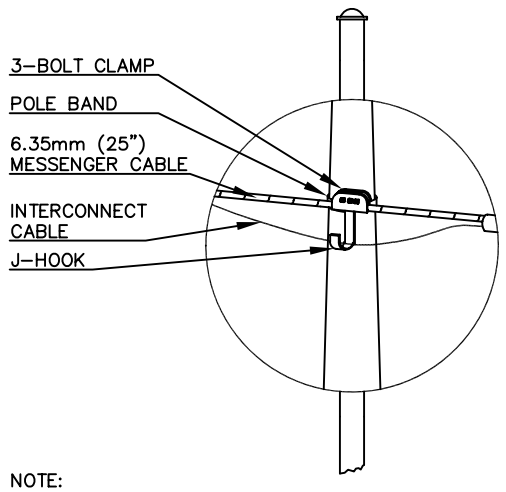
	03/01

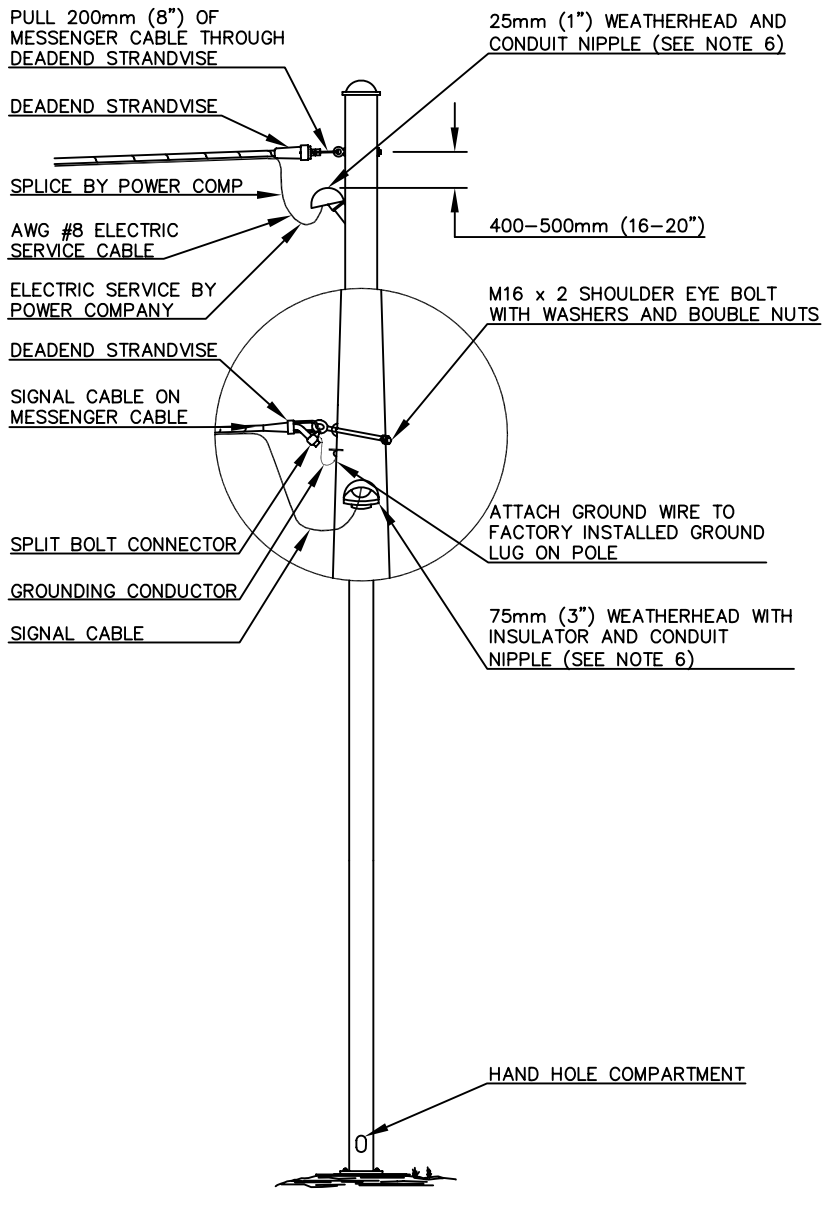
STANDARD DRAWING FOR
CONDUIT AND PULL BOX
INSTALLATION

SHEET NO.
SIG-6

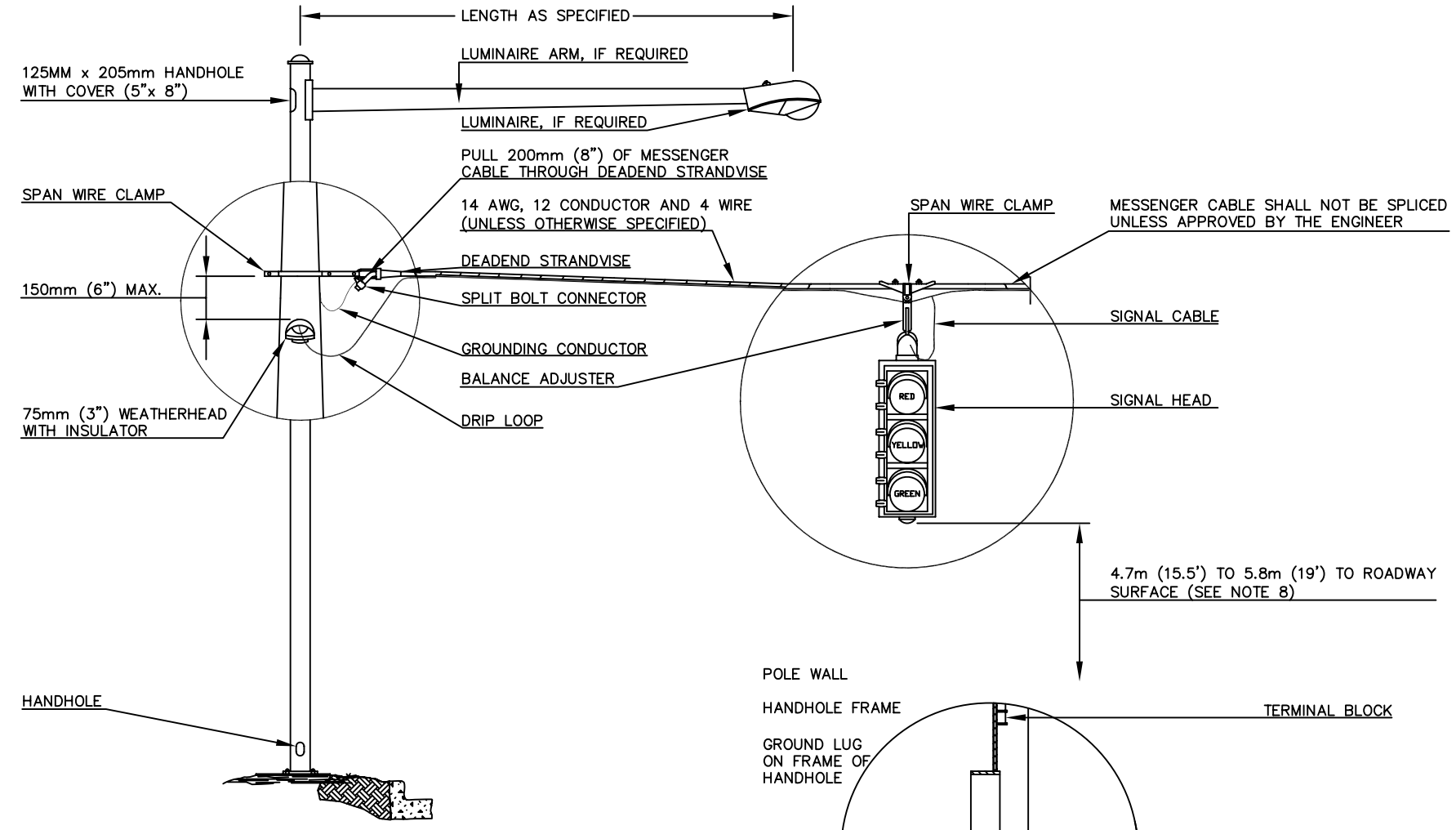


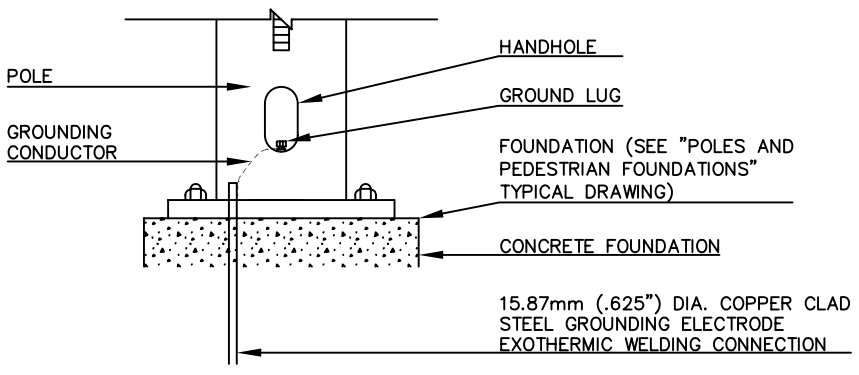
NOTE:
SEE "INTERCONNECT CABLE AT INTERMEDIATE POLE" DETAIL ON "VARIOUS INSTALLATIONS ON WOOD POLES" TYPICAL DRAWING FOR CABLE INSTALLATION DETAILS.

ATTACHMENT OF CABLE TO INTERMEDIATE METAL POLE



STRAIN POLE WITH CONTROLLER CABINET WIRE AND CABLES INSIDE POLE



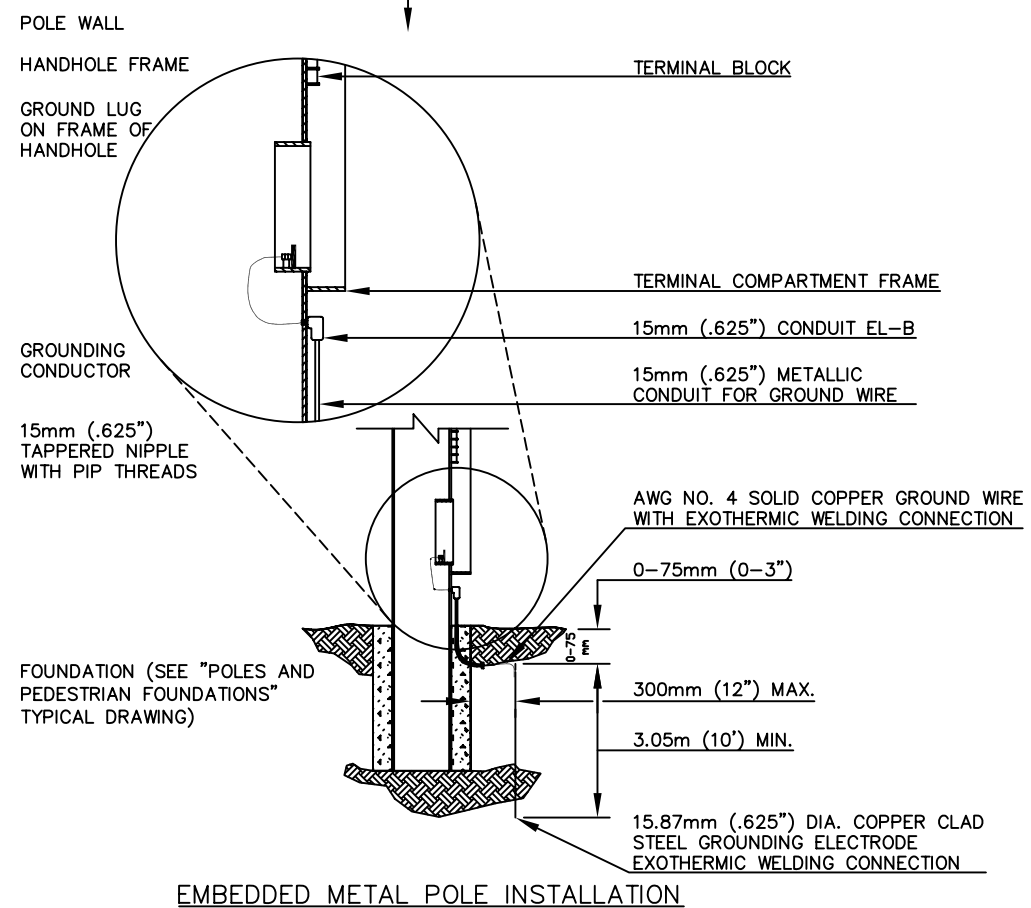


METAL POLE GROUNDING DETAIL

NOTE:

DESIGN BASED ON STIFF CLAY SOILS HAVING AN ANGLE ON INTERNAL FRICTIONS OF APPROXIMATELY 30 DEGREES AND A MINIMUM UNIT WEIGHT OF 15.7 kN/m^3. SOIL CHARACTERISTICS SHALL BE VERIFIED BY THE ENGINEER PRIOR TO PROCEEDING.

DRILLED PIER FOUNDATION SCHEDULE			
STRAIN WIRE LENGTH m (')	"D" DIAMETER OF DRILLED PIER m (')	"L" DEPTH OF DRILLED PIER BELOW GRADE m (')	"V" NO. AND SIZE OF VERTICAL REBAR
30 (100')	1.07 (3')	2.50 (8')	18 – #25
45 (150')	1.07 (3')	3.05 (10')	18 – #25
60 (200')	1.07 (3')	3.70 (12')	18 – #25



EMBEDDED METAL POLE INSTALLATION

NOTES:
SEE "ELECTRICAL SERVICE DETAILS" TYPICAL DRAWINGS.

SEE "TRAFFIC SIGNAL SUPPORT FOUNDATIONS' TYPICAL DRAWINGS FOR FOUNDATIONS DESIGN.

POLES TO BE GALVANIZED ACCORDING TO ASTM A-123.

ALL HARDWARE TO BE HOT DIPPED GALVANIZED IN ACCORDANCE WITH ASTM A-153, EXCEPT THAT WEATHERHEADS SHALL BE ALUMINUM.

CONDUIT NIPPLES FOR WEATHERHEADS AND HALF COUPLINGS FOR CABINETS SHALL BE FABRICATED AT FACTORY AS PART OF POLE.

SEE "AERIAL CABLE SPLICES" TYPICAL DRAWING FOR SPLICING SIGNAL AND INTERCONNECT CABLES.

PREFERRED HEIGHT OF SIGNAL HEADS ABOVE ROADWAY SURFACE IS 5.1m (16.5').

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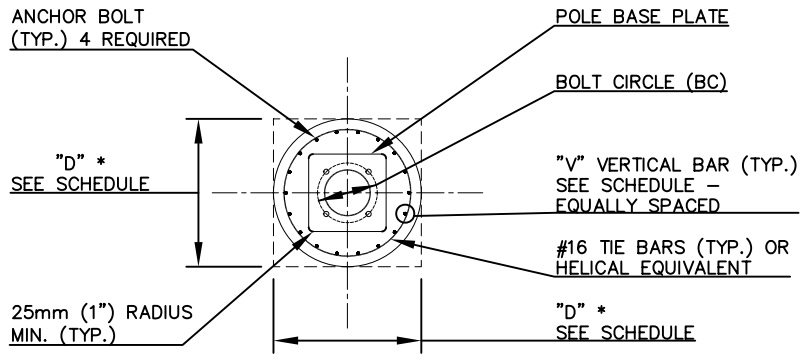
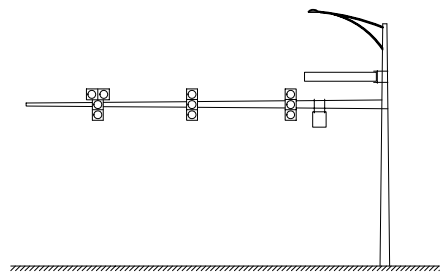
STANDARD DRAWING FOR
STRAIN POLE INSTALLATION

SHEET NO.
SIG-7

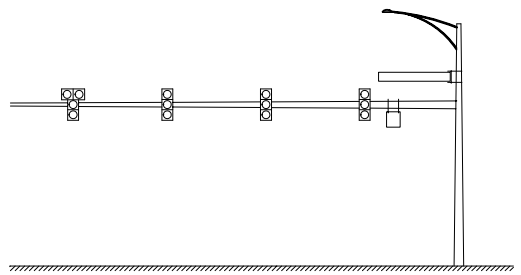


* DIAMETER IF CIRCULAR OR IF THE SIDE IS SQUARE

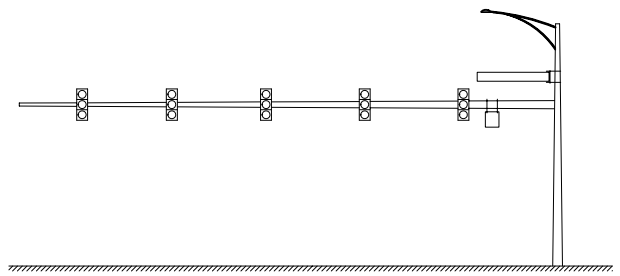
PLAN VIEW



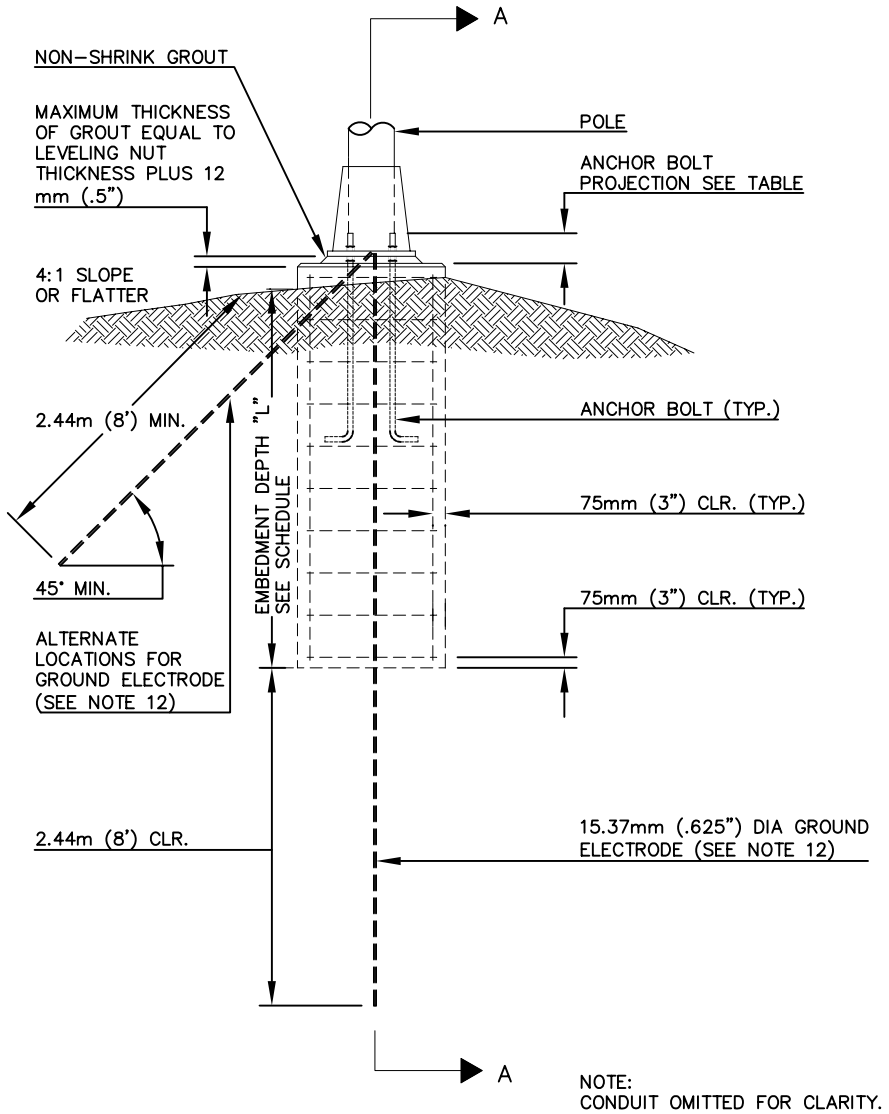
12.2m (40') MAST ARM



15.2m (50') MAST ARM

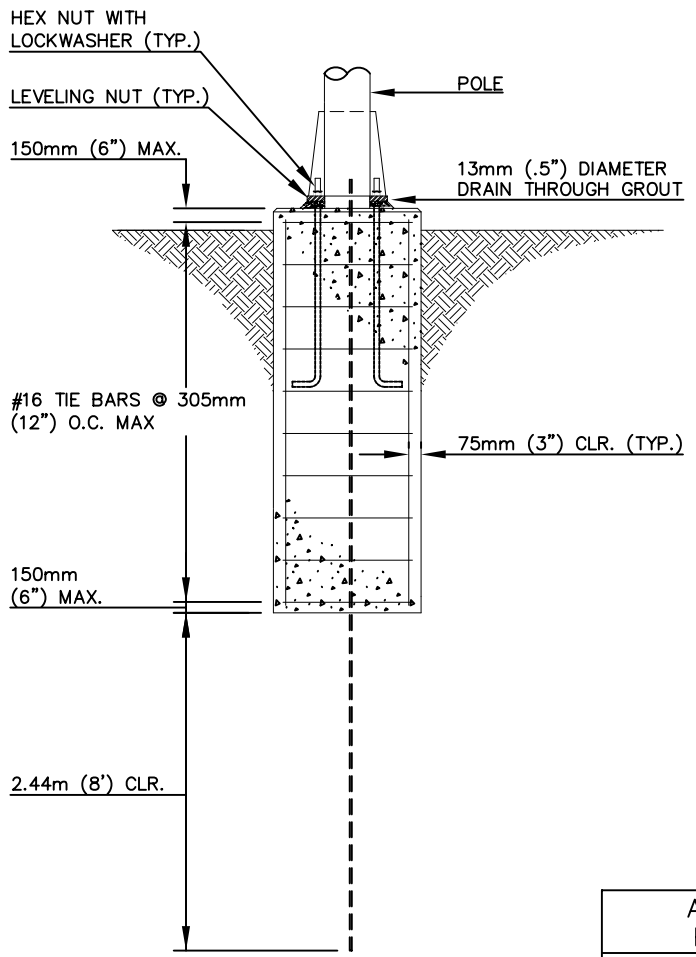


18.3m (60') MAST ARM



NOTE:
CONDUIT OMITTED FOR CLARITY.

ELEVATION



SECTION A–A

NOTES:

1. REINFORCING STEEL FOR TIE BARS AND VERTICAL BARS SHALL BE ASTM A615M GRADE 400 MPa DEFORMED.
2. FOUNDATION EXCAVATION SHALL CONFORM TO THE APPLICABLE PROVISIONS OF SECTION 410 OF THE NCDOT STANDARD SPECIFICATIONS FOR ROADS AND STRUCTURES. THE SIDES OF THE EXCAVATIONS FOR POLE FOUNDATIONS SHALL CONFORM AS NEARLY AS PRACTICAL TO THE REQUIRED DIMENSIONS. IF SIGNIFICANT DISCONTINUITIES IN THE REQUIRED CONFIGURATIONS OF THE EXCAVATIONS FOR A POLE FOUNDATION ARE CREATED BY THE REMOVAL OF BOULDERS OR AS A RESULT OF OTHER CAUSES, THE EXCAVATION SHALL BE BACKFILLED AND COMPACTED AS PROVIDED FOR IN SECTION 410 OF THE NCDOT STANDARD SPECIFICATIONS. THE EXCAVATION SHALL THEN BE REMADE TO THE PROPER DIMENSIONS.
3. CONCRETE SHALL BE PLACED AGAINST UNDISTURBED SOIL.
4. IF ROCK OR BOULDERS ARE ENCOUNTERED DURING THE EXCAVATION, THEY SHALL BE REMOVE TO A DEPTH SUFFICIENT TO OBTAIN THE STABILITY NECESSARY TO SUPPORT THE STRUCTURE.
5. IF SHORING IS REQUIRED IN CONJUNCTION WITH EXCAVATION FOR POLE FOUNDATIONS TO KEEP SOIL FROM COLLAPSING, IT SHALL BE AN INSIDE DIAMETER SMOOTH PIPE EQUAL TO THE OUTSIDE DIAMETER OF THE POLE FOUNDATION SHOWN ON THE PLAN. THE SMOOTH PIP SHALL RETRACTED AS CONCRETE IS CAST. THE OPERATION SHALL BE CONDUCTED IN A MANNER THAT ALLOWS NO WATER TO ACCUMULATE IMMEDIATELY BEFORE AND DURING CONCRETE CASTING OPERATION.
6. THE TRAFFIC SIGNAL STRUCTURE (POLE) SHALL NOT BE ERECTED BEFORE CONCRETE IN THE FOUNDATION HAS ATTAINED A MINIMUM STRENGTH OF 21 MPa.
7. CONCRETE FOR POLE FOUNDATIONS SHALE BE CLASS "A" IN ACCORDANCE WITH NCDOT STANDARD SPECIFICATIONS FOR ROADS AND STRUCTURES.
8. WHEN THE FOUNDATION IS PLACED IN ESSENTIALLY LEVEL SIDEWALK, THE TOP THE THE FOUNDATION SHALL BE FLUSH WITH THE SIDEWALK SURFACE.
9. ANCHOR BOLTS, NUTS AND WASHERS SHALL CONFORM THE THE REQUIREMENTS OF THE NCDOT STANDARD SPECIFICATIONS FOR ROADS AND STRUCTURES.
10. ANCHOR BOLTS SHALL BE PROVIDED BY THE POLE MANUFACTURE. THE ANCHOR BOLTS SHALL BE SUPPLIED WITH A TEMPLATE FOR SETTING THE BOLTS. THE ANCHOR BOLTS SHALL HAVE A MINIMUM YIELD STRENGTH OF 380 MPa AND SHALL BE GALVANIZED (ASTM A153) FOR A MINIMUM OF 305mm (12") ON THE EXPOSED END.
11. ANCHOR BOLTS SHALL VE PROVIDED WITH THREADS WHICH EXTEND A MINIMUM OF 75mm (3") BELOW THE TOP OF THE FOUNDATION.
12. A GROUND ELECTRODE SHALL BE DRIVEN AT LEAST 2.44m (8') INTO UNDISTURBED EARTH AND SHALL BE DRIVEN INTO THE EARTH EITHER BENEATH OR BESIDE THE FOUNDATION.
13. USE NON–SHRINKING GROUT BETWEEN THE BASE PLATE AND FOUNDATION CONCRETE AS SHOWN ON THE DRAWINGS.

ANCHOR BOLT PROJECTIONS	
BOLT DIAMETER "mm" (")	PROJECTION "mm" (")
38.1 (1.5")	205 (8")
44.5 (1.75")	205 (8")
50.8 (2")	216 (8.5")
57.2 (2.25")	230 (9")
63.5 (2.5")	242 (9.5")

NOTE:

DESIGN BASED ON STIFF CLAY SOILS HAVING AN ANGLE ON INTERNAL FRICTION OF APPROXIMATELY 30 DEGREES AND A MINIMUM UNIT WEIGHT OF 15.7 kN/m^3. SOIL CHARACTERISTICS SHALL BE VERIFIED BY THE ENGINEER PRIOR TO PROCEEDING.

DRILLED PIER FOUNDATION SCHEDULE			
STRAIN WIRE LENGTH m (')	"D" DIAMETER OF DRILLED PIER m (')	"L" DEPTH OF DRILLED PIER BELOW GRADE m (')	"V" NO. AND SIZE OF VERTICAL REBAR
12.2 (40')	1.00 (3.25')	2.15 (7')	13 – #25
15.2 (50')	1.00 (3.25')	2.75 (9')	13 – #25
18.3 (60')	1.22 (4')	3.35 (11')	19 – #29

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STANDARD DRAWING FOR
FOUNDATION FOR STEEL POLE/
MAST ARM TRAFFIC SIGNAL INSTALLATION
12.2 m, 15.2 m AND 18.3 MAST ARMS
(METRIC UNITS)

SHEET NO.
SIG–8

FIGURE 1

PULSE DETECTION CONFIGURATION DETAILS

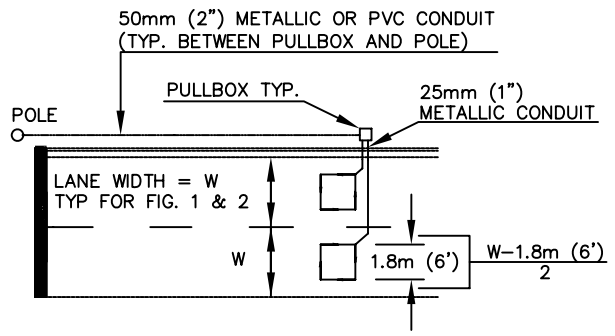
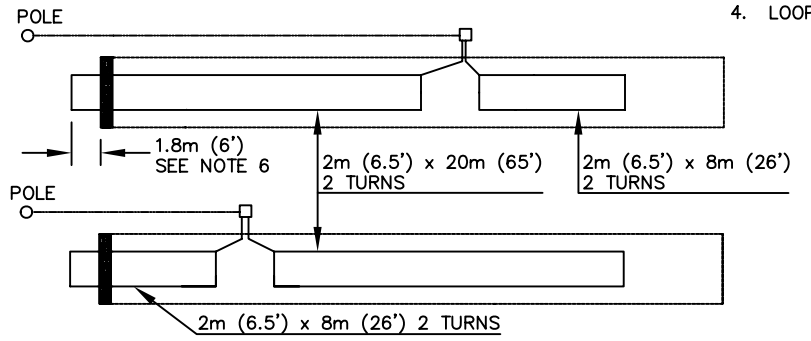


FIGURE 2

PRESENCE DETECTION CONFIGURATION DETAILS



1. MAINTAIN 300mm (12") SPACING BETWEEN LEAD IN CABLES IN PAVEMENT.
2. ALTERNATE POLARITY OF ADJACENT LOOPS ATTACHED TO THE SAME DETECTOR UNIT.
3. PLACE LOOP WIRES IN A 20mm (1") x 300mm (12") PVC SLEEVE WHERE PAVEMENT MATERIALS CHANGE.
4. LOOP SHOULD BE PLACED 1.8m (6') BEYOND STOPBAR UNLESS OTHERWISE NOTED ON PLANS.

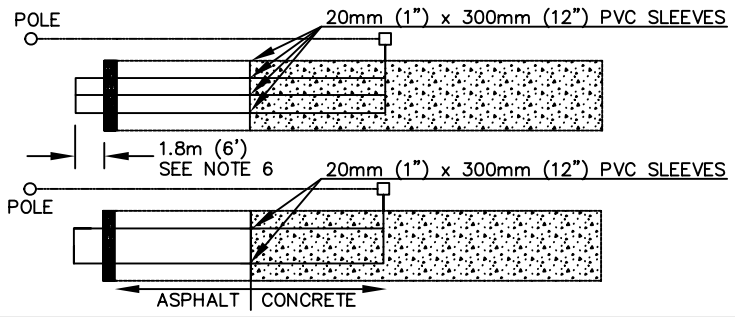
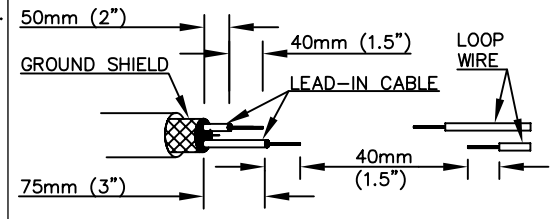
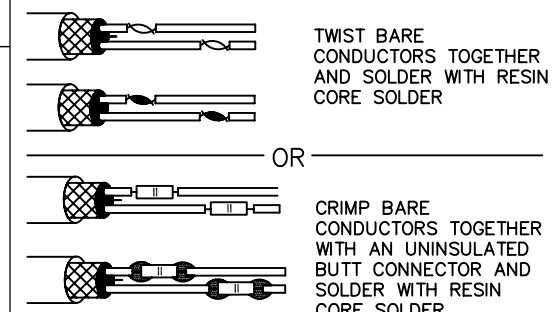


FIGURE 7

SPLICING FOR LEAD–IN CABLE AND LOOP WIRE



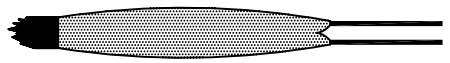
STEP 1. STRIP LOOP WIRE AND LEAD–IN CABLE


TWIST BARE CONDUCTORS TOGETHER AND SOLDER WITH RESIN CORE SOLDER
OR
CRIMP BARE CONDUCTORS TOGETHER WITH AN UNINSULATED BUTT CONNECTOR AND SOLDER WITH RESIN CORE SOLDER

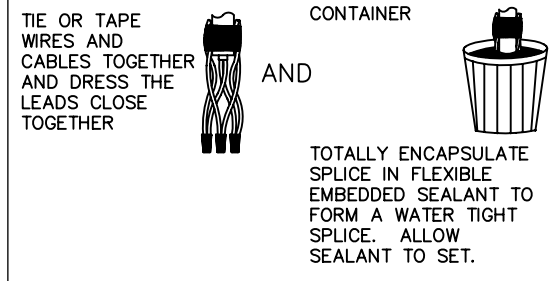
BOND GROUND SHIELD AT SPLICE SECTIONS (DO NOT GROUND)

STEP 2. CONNECT AND SOLDER (REFER TO FIG. 6)

STEP 3. INSULATE EACH SOLDER JOINT SEPARATELY



OR


TIE OR TAPE WIRES AND CABLES TOGETHER AND DRESS THE LEADS CLOSE TOGETHER
AND
SMALL PAPER CUP OR OTHER SUITABLE CONTAINER
TOTALLY ENCAPSULATE SPLICE IN FLEXIBLE EMBEDDED SEALANT TO FORM A WATER TIGHT SPLICE. ALLOW SEALANT TO SET.

STEP 4. ENVIRONMENTALLY PROTECT TOTAL SPLICE WITH MOSITURE PROOK SEALANT SPLICE KIT, OR 2 LAYERS OF ELECTRICAL TAPE.

GENERAL NOTES:

1. NUMBER OF TURNS OF WIRE IN EACH LOOP SHALL BE THE NUMBER INDICATED ON THE SIGNAL PLAN.
2. LOOP DIMENSIONS AND LOCATIONS SHALL BE AS SHOWN ON SIGNAL PLANS.
3. LOOPS SHALL BE LOCATED IN CENTER OF LANES.

CONVENTIONAL 4 SIDED LOOP

SAW CUT OPTIONS

OPTION 1

OPTION 2

LOOP WINDING METHOD

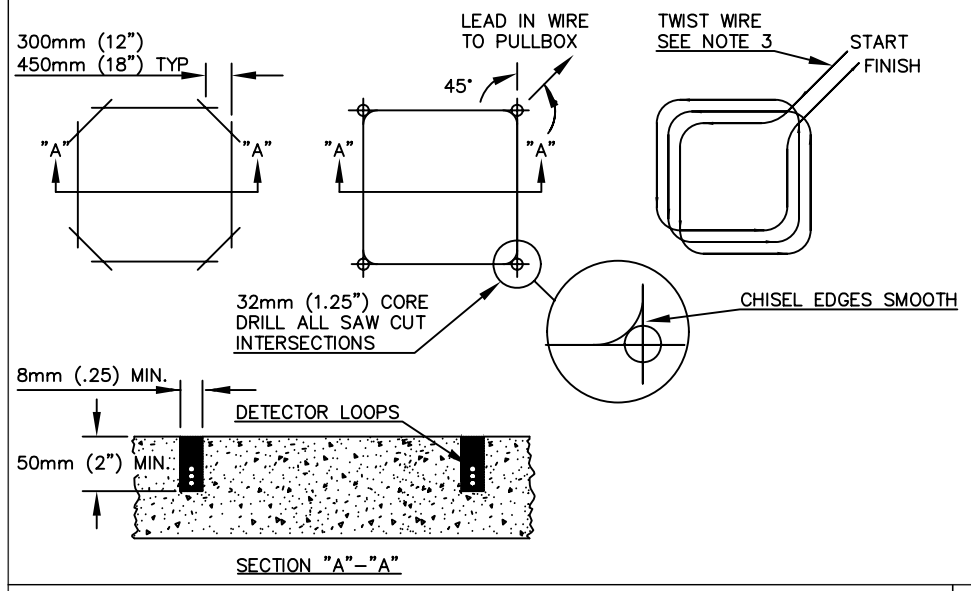


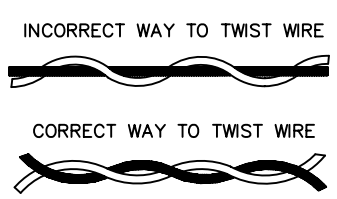
FIGURE 3

LOOP WINDING AND SAW CUT DETAILS

NOTES:

1. OVERLAP SAW CUTS AT CORNERS AND INTERSECTION POINTS TO ENSURE UNIFORM SAW SLOT DEPTH.
2. TAG AND LABEL LOOP WIRE LEADS TO FACILITATE THE SPLICING OF SERIES AND ALTERNATE POLARITY CONNECTIONS.
3. TWIST LOOP WIRE LEADS SYMMETRICALLY FROM THE LOOP TO THE PULL BOX AT A RATE OF NOT LESS THAN 5 TWIST PER FOOT.

LOOP WIRE TWISTING METHOD



QUADRUPLE 4 SIDED LOOP

SAW CUT OPTIONS

OPTION 1

OPTION 2

LOOP WINDING METHOD

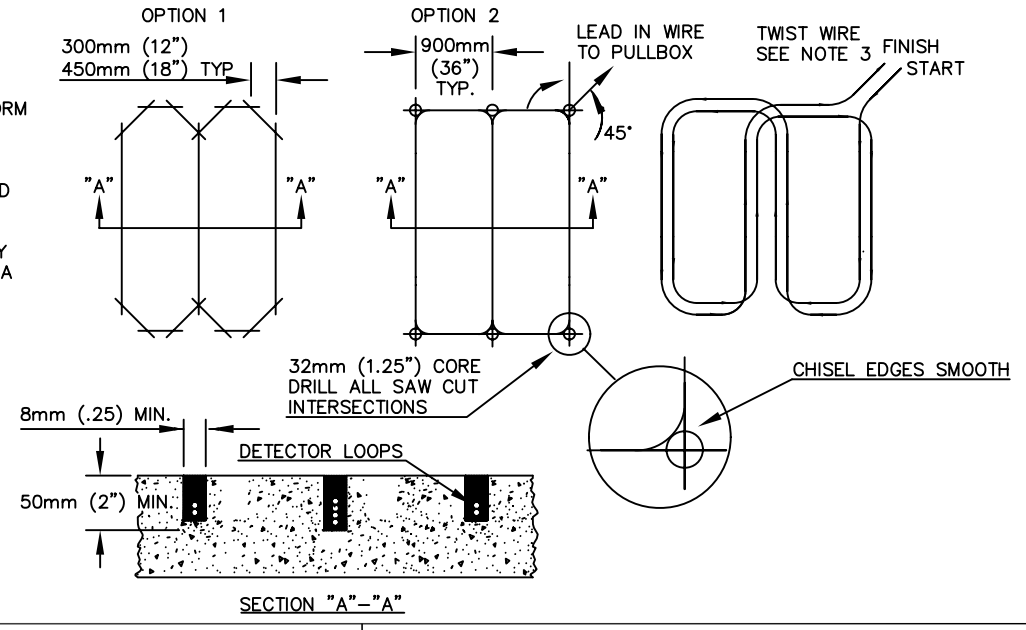
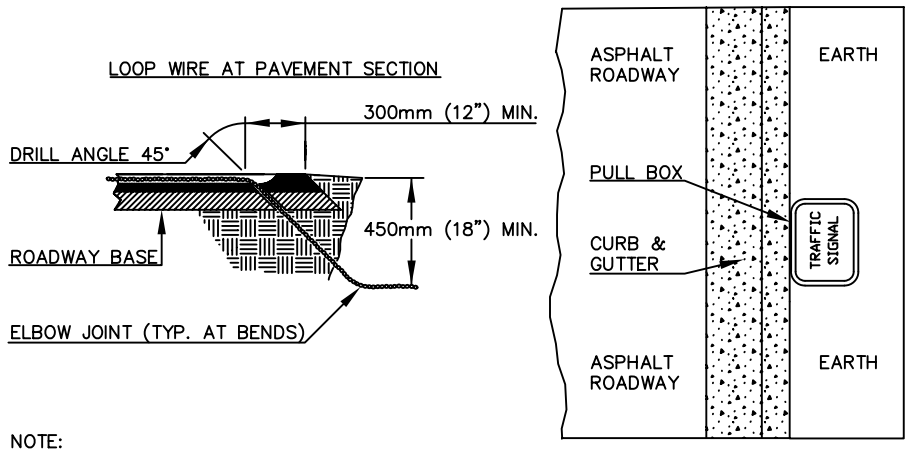


FIGURE 4

LOOP WIRE PAVEMENT EDGE DETAILS

LOOP WIRE AT PAVEMENT SECTION



NOTE:

1. AFTER LOOP WIRE IS PLACED INTO SAW SLOTS, AND PRIOR TO SEALING SAW SLOTS OR SPLICING LOOP WIRE LEAD–INS TO LEAD–IN (HOMERUN) CABLE, CHECK ELECTRICAL CONTINUITY OF LOOP AT LOOP WIRE LEADS TO CONFIRM ACCEPTABLE INSULATION RESISTANCE.

LOOP WIRE AT CURB & GUTTER SECTION

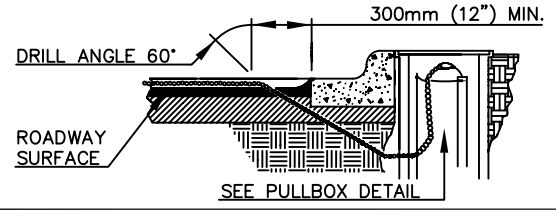
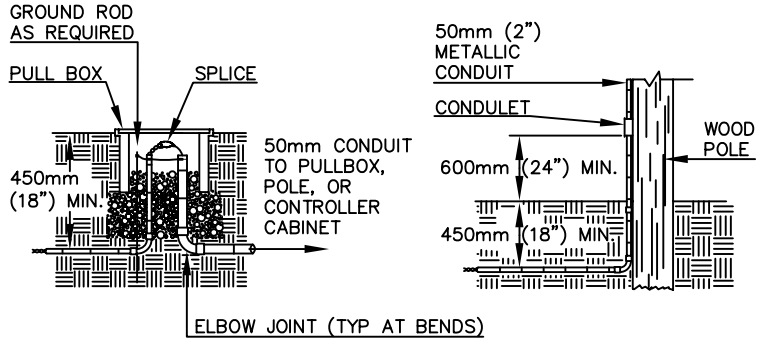


FIGURE 5

LOOP WIRE SPLICE POINT DETAILS

LOOP WIRE AT PULLBOX

LOOP WIRE AT POLE



NOTES:

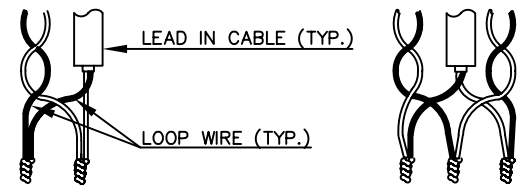
1. ALL LOOP WIRE/HOME RUN CABLE SPLICES SHALL BE MADE IN PULL BOXES OR APPROVED CONDULETS.
2. PULL BOXES SHOULD BE LOCATED AT THE BACK OR CURB. FOR PAVEMENT SECTIONS, PULL BOXES SHOULD BE LOCATED A MINIMUM OF 1.8m (6') FROM THE PAVEMENT EDGE, OR WITHIN THE RIGHT OF WAY.
3. HEAVY DUTY PULL BOX COVER REQUIRED FOR THE SHOULDER INSTALLATIONS.

FIGURE 6

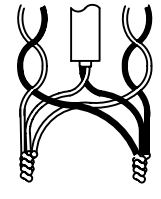
LOOP WIRE AND LEAD–IN CABLE CONNECTION DETAILS

SINGLE CONNECTION

SERIES CONNECTION



PARALLEL CONNECTION



NOTE:

MUTIPLE CONNECTIONS WILL BE MADE PARALLEL UNLESS OTHERWISE SPECIFIED.

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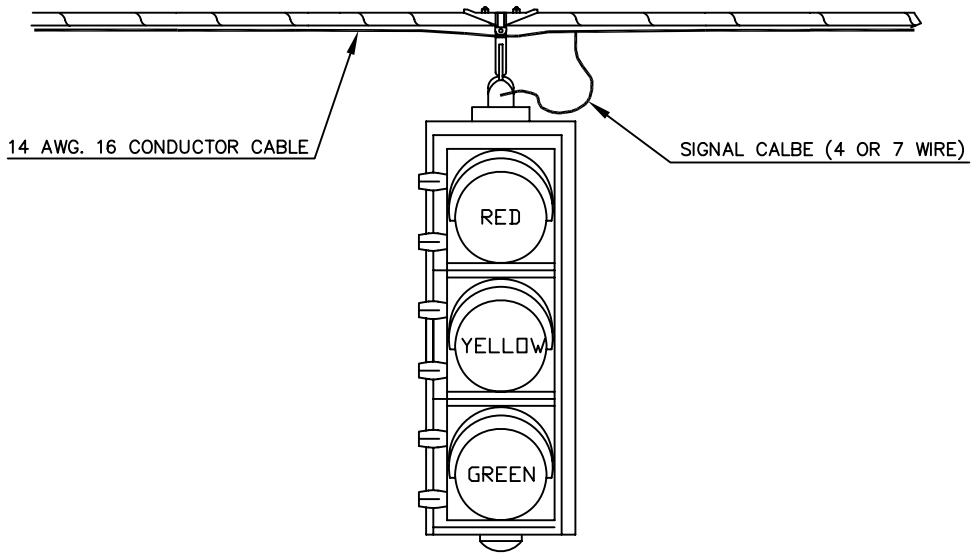
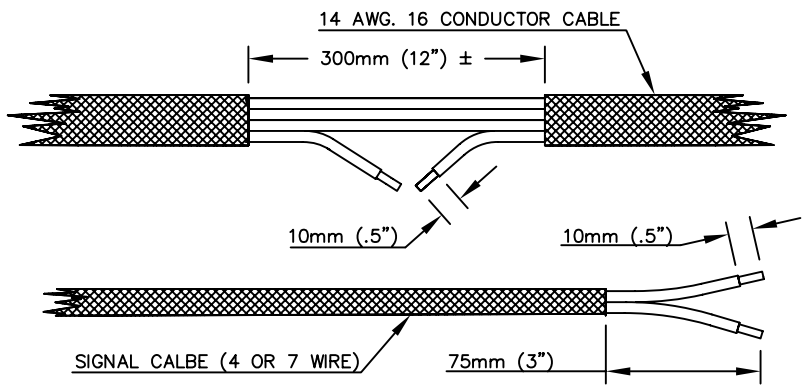
STANDARD DRAWING FOR
INDUCTIVE LOOP INSTALLATION

SHEET NO.
SIG–9

SPLICING SIGNAL CABLE INTO 16 CONDUCTOR CABLE

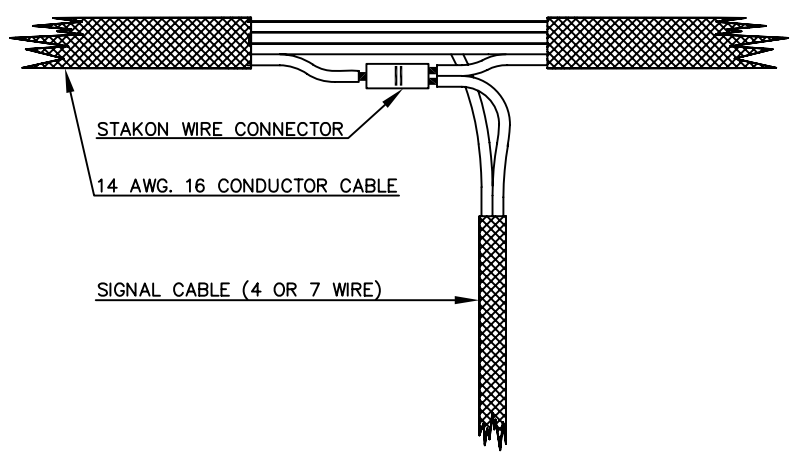


STEP 1. STRIP SIGNAL CABLE AND 16 CONDUCTOR CABLE



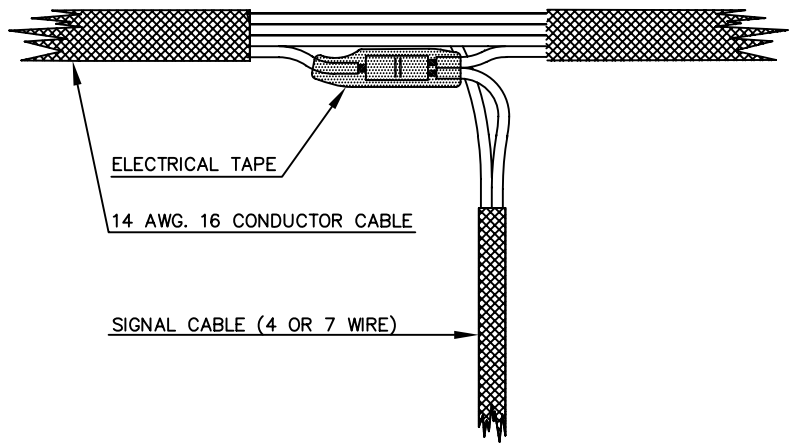
STRIP THE APPROPRIATE WIRES FROM THE 16 CONDUCTOR CABLE FOR EACH SIGNAL INSTALLATION. SEE THE COLOR CODING CHART IN SECTION 17.7.1.5 OF THE CDOT SIGNAL SPECIFICATIONS TO DETERMINE THE PROPER WIRES TO STRIP AT EACH LOCATION.

STEP 2. CONNECT SIGNAL CABLE TO 16 CONDUCTOR CABLE



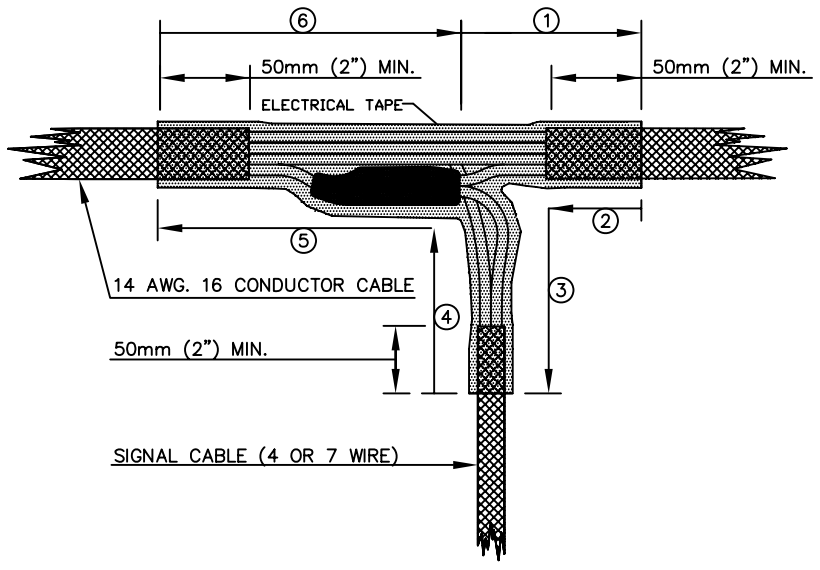
CONNECT ALL WIRES USING STAKON WIRE CONNECTORS ACCORDING TO THE COLOR CODING CHART SHOWN IN SECTION 17.7.1.5 OF THE CDOT SIGNAL SPECIFICATIONS.

STEP 3. INSULATE EACH INDIVIDUAL SPLICE



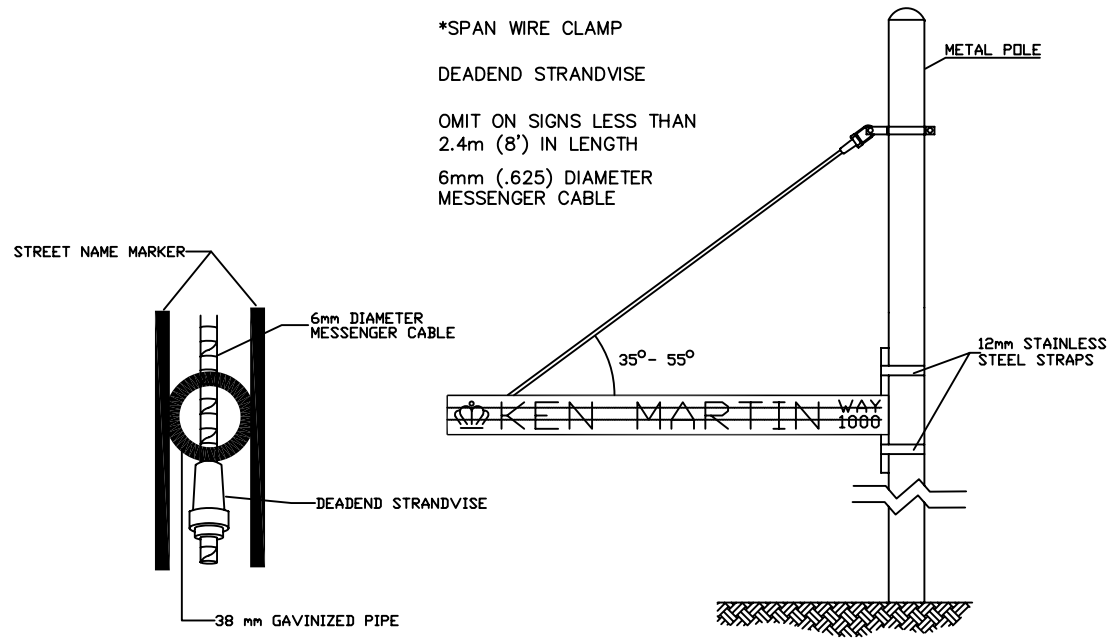
INSULATE ALL SPLICES WITH 2 REVOLUTIONS (MINIMUM) OF ELECTRICAL TAPE.

STEP 4. INSULATE THE ENTIRE SPLICE

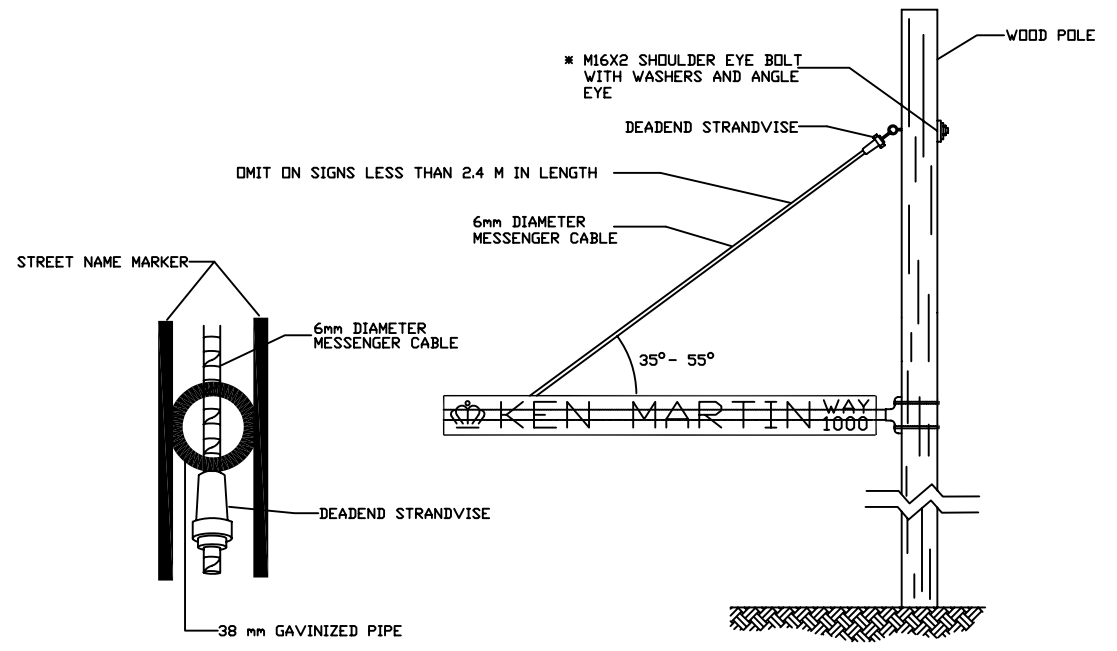


WRAP THE ENTIRE SPLICE WITH ELECTRICAL TAPE. WRAP THE SPLICE ACCORDING TO THE NUMBERED ARROWS ABOVE, BEGINNING AT LOCATION #1 AND ENDING AT LOCATION #6.

INSTALLATION OF STREET NAME MARKERS



*MAY USE SPAN WIRE CLAMP OR EYE BOLT WHICH IS SUPPORTING THE SIGNAL SPAN IF SIGNAL SPAN IS IN THE SAME DIRECTION AS THE SUPPORT CABLE.



* MAY USE SPAN WIRE CLAMP OR EYE BOLT WHICH IS SUPPORTING THE SIGNAL SPAN IF SIGNAL SPAN IS IN THE SAME DIRECTION AS THE SUPPORT CABLE.

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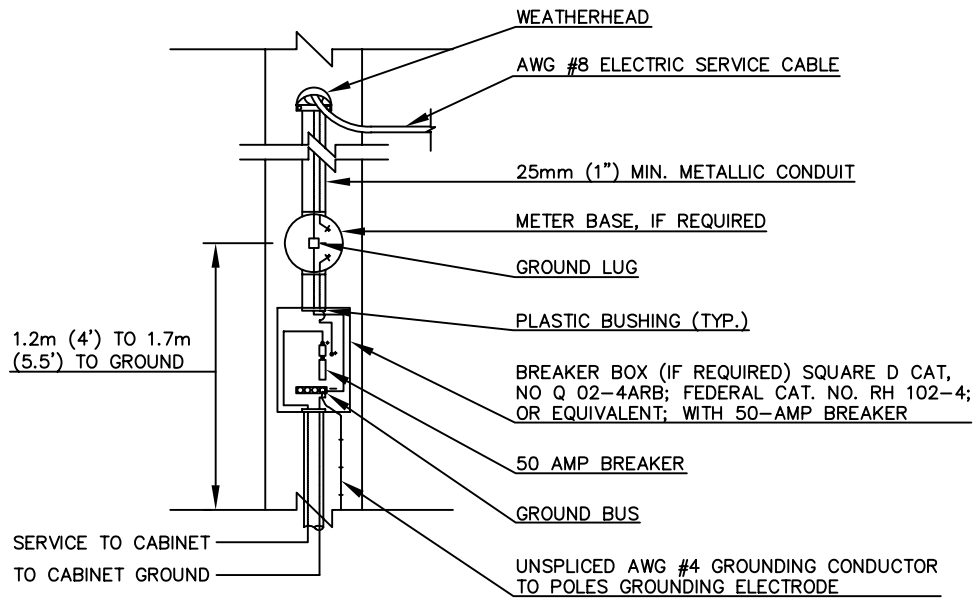
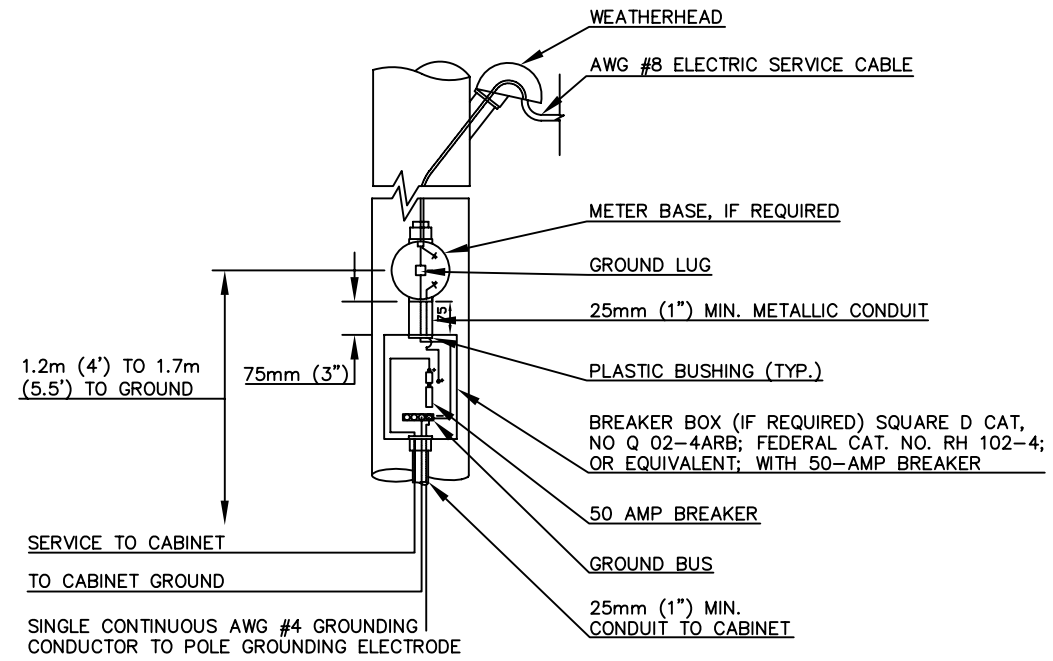
STANDARD DRAWING FOR
SIGNAL CABLE SPLICING
STREET NAME MARKER INSTALLATIONS

SHEET NO.
SIG-10



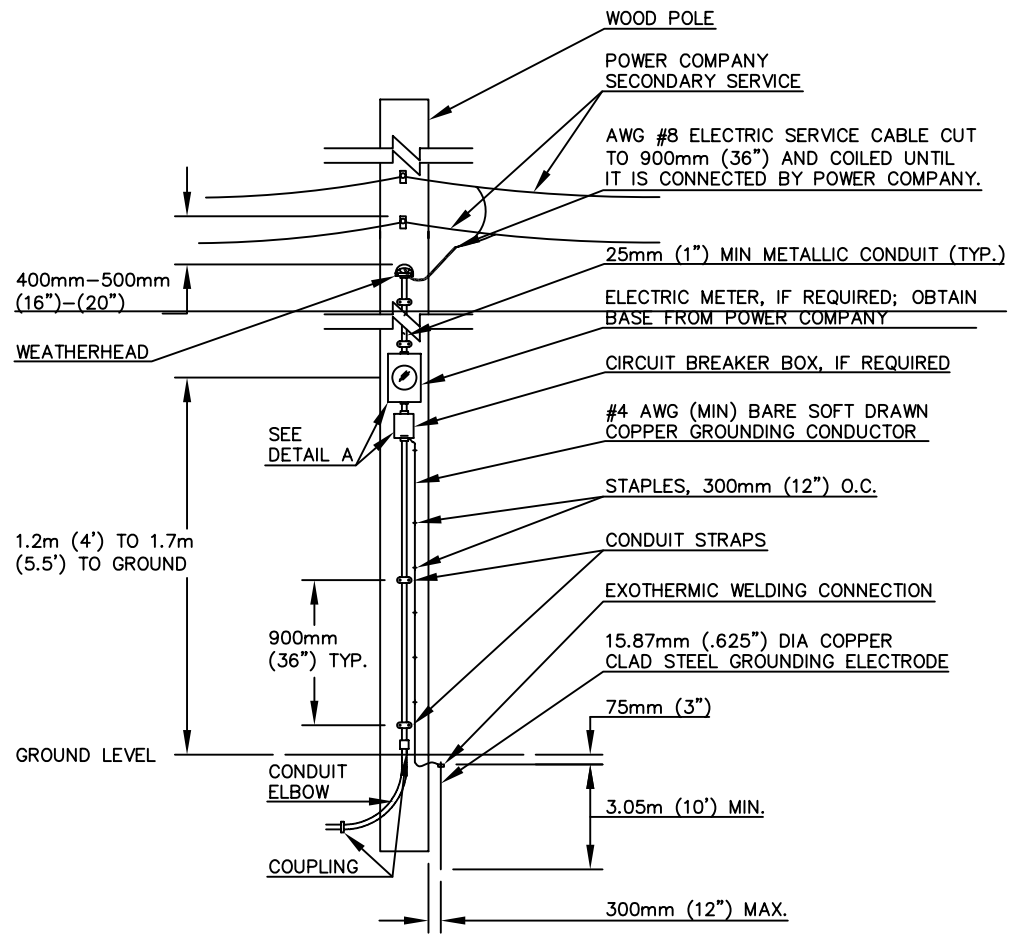
DETAIL A, SERVICE DETAIL ON WOOD POLE

(120 VOLT SERVICE)



DETAIL B, SERVICE DETAIL ON METAL POLE

(120 VOLT SERVICE)



NOTE: WOOD POLE LENGTH SHALL BE 10.5m (35') MINIMUM UNLESS OTHERWISE NOTED.

DETAIL C, SERVICE DETAIL ON WOOD POLE

SCHEMATIC CONNECTION OF POWER METER AND EXTERNAL CIRCUIT BREAKERS TO SERVE TRAFFIC SIGNALS

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STANDARD DRAWING FOR
ELECTRIC SERVICE DETAILS

SHEET NO.
SIG-11